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ABSTRACT

This collection of activities revolves around the theme of National Science and Technology Week (NSTW). The six 8-page booklets that make up this package present activities that follow a pathway from natural, simple forms of communication toward increasingly complex and technological forms. They are designed to be undertaken in sequence, but can also stand alone as independent units. The activities are for a variety of ages and all have features of assessment, extension, and home/community connection. The package also contains a booklet that presents a wide range of resources that can be used to extend the activities and a poster depicting NSTW. The science content topics covered in the units include natural languages, using codes, the nature of sound, the electromagnetic spectrum, networks, and decoding space images. (DDR)

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ED 462 254

Crack a Secret Code
Make a Radio Speaker
Build a Ping-Pong Network

INSIDE...

16 creative, hands-on activities designed to help children understand the technologies that help us communicate.

APRIL 20-26, 1997

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WEBS wires WAVES

The Science & Technology of Communication

NATIONAL SCIENCE & TECHNOLOGY WEEK **National Science Foundation**

Scents and Sense Abilities

The Languages of Nature

Overview

Children will model and explore various natural (non-technological) methods of animal communication, each involving the senses of sight, sound, touch, or smell. These activities also introduce the concept *(expanded in Booklets 3 and 4)* of vibration as the foundation of all sound.

Skills

- Observing
- Comparing
- Modeling
- Inferring
- Problem Solving
- Communicating

Subject Areas

- Animal Science
- Language Arts
- Physics

Estimated Time and Age Level

- *Going Through the Motions*
  One 30-minute session
  (ages 5-10)
- *Calls of the Wild*
  One 30-minute session
  (ages 6-10)
- *The Nose Knows*
  One 45-minute session
  (ages 6-12)

How do animals communicate without using words?

4

WEBS wires WAVES
The Science & Technology of Communication

BACKGROUND

Talking Point One famous animal "communicator" is a wild dolphin named Jo Jo, who appears to prefer the company of humans at a beach resort near her home waters to that of dolphins. When the normally playful dolphin began to bite swimmers and push them into deeper waters, scientist Patricia St. John was called in to study the behavior of both Jo Jo and the humans. What she discovered was a breakdown in communication—a language barrier that neither species had figured out how to cross. When Jo Jo used dolphin body language to say "back off," humans didn't understand. Likewise, Jo Jo didn't understand that flailing humans were desperate to go back to shallow water.

How could this language gulf be bridged? The answer for St. John was to invent a shared, visual language between the humans and the dolphin. She taught Jo Jo to recognize visual hand signals, including one for "No!" And she taught the humans how to read dolphin body language.

Sensory Signals Just as humans do, other animals use their senses (principally sight, sound, smell, and touch) in countless ways to transmit and receive messages naturally—that is, without assistance from technologies such as telephones or radios. Some examples:

Communicating by touch or movement

- The tiny male black widow spider signals the larger, often cannibalistic female not to eat him by vibrating her web at a certain frequency and pulse.
- Honeybees perform "waggle dances" to communicate to other bees where they can find food. A round dance indicates a nearby food source; a figure eight indicates a distant food source.

Communicating by scent

- Deer have special scent glands on their feet and heads that they use to mark paths they have traveled in the woods.
- Many adult female animals lick their offspring thoroughly after birth. This action helps the parent learn the unique scent of her babies.

Communicating by sound

- Sound is produced by vibrating objects. Humans, other animals, and insects produce vibrations in myriad ways: by stimulating vocal cords, for example, or by blowing across a windpipe (howler monkey), or by rubbing legs against wings (grasshopper).

The point of the story of Jo Jo the dolphin (see lefthand column, as well as Activity 1) is that communication, by definition, is a two-way street. A message may be sent, but in order for it to count as communication, it must be received—and understood. Animals (including humans) have developed countless, complex ways to accomplish this feat—even between species, as most pet owners know. In the activities that follow, children will explore a number of fascinating methods animals use to communicate.

BACKGROUND RESOURCES

Making Sense: Animal Perception and Communication, by Bruce Brooks (Farrar, Straus & Giroux, 1993). General overview of animal communication.

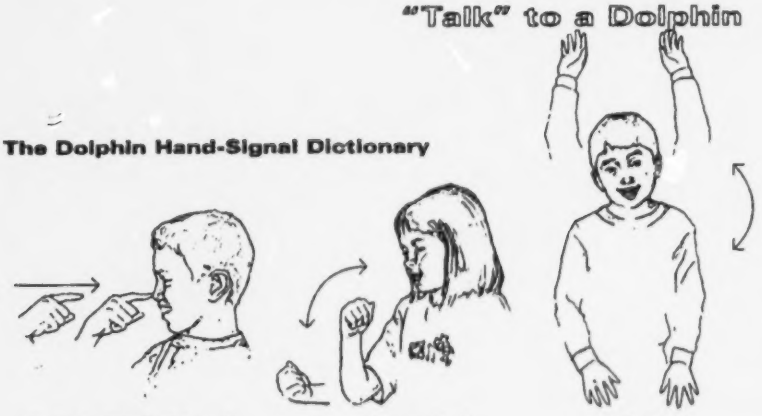
Signs of the Apes, Songs of the Whales: Adventures in Animal Communication, by George Harrar (Simon & Schuster, 1989). Explorations in human-to-animal communication.

ACTIVITY ONE

Going Through the Motions

"Talk" to a Dolphin

The Dolphin Hand-Signal Dictionary



Touch Beak (Nose) | Toss Ball | Get Ball

Procedure

1. Divide the group into teams of five children each. Have teams sit in circles with members facing each other. Share the true story of Jo Jo from the Background section. Ask children what they think went "wrong" between Jo Jo and the swimmers. Ask how they would solve the problem. Ask what other messages they think Patricia St. John could teach Jo Jo.

2. Pass out the Hand-Signal Dictionary to each team and explain that these are actual signals used by dolphin trainers. Place a ball in the center of each circle. First, ask one member of each team to be a "dolphin" and try to respond to your signaled instruction. Repeat the signals until all team members understand how the process works.

3. Have children work in their own teams to practice the signals, taking turns as the "trainer." Then challenge the teams to create their own signals for human-to-dolphin communication, such as LOOK AT ME, JUMP STRAIGHT UP, WAIT, SPIN AROUND, etc.

4. Discuss how humans communicate with other animals. Have the children share examples of signals that they use to communicate with pets in their own homes. Do the signals always work?

Assessment

Have each team create a short "dolphin show" using their own signals. Evaluate based on how complex the messages are and how well the messages work in directing the "dolphins'" behavior.

Extension

Obtain copies of the American Sign Language alphabet from a local hearing impaired association or library, and/or invite a deaf interpreter to teach ASL to the group. Challenge children to present a short poem or letter to the group in ASL.

Resources

The Secret Language of Dolphins, by Patricia St. John (Simon and Schuster; 1991).

Overview

Children will explore nonverbal communication by modeling hand-signals used by scientists to communicate with dolphins—and by inventing some new signals of their own.

Time Frame

One 30-minute session

Suggested Age Level

Ages 5-10

Materials

- 1 Dolphin Hand-Signal Dictionary per team of five children
- A variety of soft, light balls (at least one per team)

Preparation

- Make one copy of the Dolphin Hand-Signal Dictionary for each team.

Credit

This activity was partially adapted from "How Would You Tell a Dolphin to Jump Through a Hoop?" poster; *SuperScience Blue* magazine (Scholastic Inc.; February 1996 issue).

ACTIVITY TWO

Calls of the Wild

Sound Off to Speak Up

Overview
Children will discover how animals use vibrations in different ways to make sounds and communicate with each other.

Time Frame
Preparation: 30 minutes to prepare stations
Activity: One 30-minute session

Suggested Age Level
Ages 6-10

Materials
- Station Label for each of the six Animal Sound-Off Stations *(see page 5)*
- 2 to 4 pairs of narrow-necked bottles (try different sizes, shapes and materials)
- 2 to 4 empty, clean cans with plastic lids
- 2 to 4 pencils
- 2 to 4 aluminum pie tins
- 2 to 4 small combs
- 2 to 4 stiff playing cards
- 2 to 4 thick 4-inch rubber bands
- A variety of other objects that will make sounds by rubbing, shaking, tapping, etc. (rulers, jars enclosing rattling objects, etc.)
- Paper and pencils for each team to use for taking notes

Preparation
- Copy the labels on page 5, cut them out, and tape one near each Sound-Off Station.
- Set up all or some of the following six Sound-Off Stations: howler monkey (bottles, pitcher of water); damselfish (pencils, can drums); cicada (pie tins); grasshopper (combs, playing cards); spider (4-inch rubber bands); and an "Invent-Your-Own-Animal-Sound" station with the other objects you've collected.

Procedure

1 Create as many teams as you have stations. Explain that at each Sound-Off Station, teams will be using different homemade instruments to mimic the way an animal or insect communicates. After practicing at each station, children will try to communicate a message in the "language" of one of the animals represented.

Without demonstrating each sound, suggest that youngsters look for a single characteristic that connects these "instruments." *(Though they may come up with the basic idea, you may have to supply the key word: that these instruments depend upon vibration—moving back and forth in a rhythm to produce sound.)* Challenge each team to identify that trait by moving from station to station, taking notes as they go.

2 After teams have rotated through three stations, ask them to stop and discuss what they've observed thus far. If no team points to the presence of vibrations, give them a clue. Have youngsters close their eyes and place their hands flat on the floor. Then drop a heavy book. How did they know the book had fallen? *(They heard it, but they also felt vibrations through the floor. Note: this might not work if your floor rests on concrete.)*

3 Now challenge students to give meaning to the sounds and vibrations they have learned to produce by creating three distinct messages using the "Sound-Off" device at the station where they've ended up: a warning of danger, a mating call, and a "Back off or else!" call. (Or: let them try to communicate another message of their own design.) Give them time to experiment and then ask teams to demonstrate their calls to the entire group. Other students (with their backs turned) can try to guess the meaning of each call.

Assessment

Ask teams to demonstrate to the entire group the animal sounds they devised at the "Invent-Your-Own-Animal-Sound" station. Judge according to the originality and accuracy of their efforts. Have the members of the other teams try to guess the animals being imitated and/or the messages being sent.

Extension

To imitate how human vocal cords vibrate, have youngsters cut a strip of paper about an inch wide, folding it as shown. They should then cut out a notch in the folded end, hold it up to their mouth, and blow. Ask them to experiment with papers of different thickness.

Credit

This activity was partially adapted from *SuperScience Blue* magazine (Scholastic Inc.; February 1996 issue).

Sound-Off Station Labels

The Howler Monkey sounds like a cross between a donkey and a dog. The sound is loud enough to hear three miles away! Air in the monkey's windpipe passes over two "sound boxes" with openings at their tops. To sound-off the same way, blow across the tops of empty bottles.

Damselfish make a chirping sound. They beat vibrating muscles on their swim bladder (an air sac, something like a drum, that helps the fish float). Beat lightly on the can drums to make a similar sound.

Male Cicadas are the loudest insects. They have a platelike organ called a tymbal. Like the bottom of a pie tin, it can cave in and pop out. Push the tin in and out to hear clicking noises. Cicadas can do that 500 times a second! How fast can you do it?

Grasshoppers have bumpy legs and stiff wings. They rub a leg on the edge of a wing to sound-off. Try to make a grasshopper sound by running a playing card along the teeth of the comb in a steady rhythm. Try one or more cards at a time. Is the sound different?

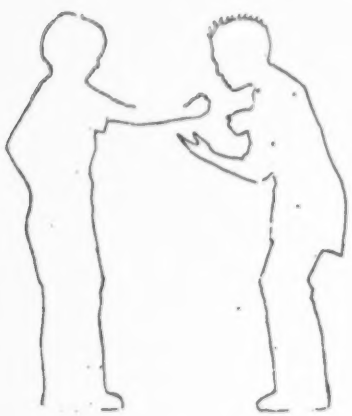
Female Spiders sometimes know whether prey or a mate has stepped onto their web. Some male spiders vibrate the web to signal, "Don't eat me!" Try it: with a partner, hold each end of a rubber band. Take turns gently twanging the band. Try closing your eyes. Can you feel the twang as well as hear it?

Invent Your Own Animal Sound!

Experiment with the objects at this station. Can you think of a way to use them (by rubbing, shaking, tapping, or blowing) to model sounds you know are made by a particular animal or insect?

The Nose Knows

When a Scent Is Worth a Thousand Words



Overview
By acting as pairs of penguin "parents" and "babies," children will explore how animals use scent to communicate.

Time Frame
Preparation: 30 minutes the night before
Activity: One 45-minute session

Suggested Age Level
Ages 6-12

Materials
- Five strongly scented, non-toxic liquids such as vanilla, peppermint, oil of cloves, vinegar, and almond extract (oil-based extracts work best and can be obtained at a lotion store or the local grocery)

Assuming a group size of 30:
- 15 cotton balls
- 15 small plastic 35mm film containers with lids
- Permanent marker and masking tape (to make labels)

Preparation
- Contact a local store that develops film or ask a photographer to save film containers with lids. You will need half as many as the total number in your group or class.
- At least one day before the activity, prepare three identical containers with each of the five scents in the following way: Wet three cotton balls with one scented liquid. Place each cotton ball inside a film container. Seal container with lid. Label the lids and container bottoms with obscure codes such as "V" on the bottom and "L" on the lid for vanilla. *(Make the container and lid codes different from each other so children can't match them visually.)* To transfer the scent on the cotton ball to the lid, store upside down overnight. Repeat these steps for each scented liquid.
- Just before conducting the activity, shake the containers one last time.
- Remove the lids and place in one location. Place the container bottoms in a separate but nearby location.
- Be sure to have the same number of lids laid out as containers. The total should equal your group size.

Procedure

1 Explain that the population of a penguin rookery (nesting site) can number well into the thousands. The noise is deafening. How could a lost chick find its parents in such a crowd? Humans recognize each other by sight and sometimes by sound. What about smell?

2 Divide the group into two sets. Give each person in one of the sets one of the 15 scent container bottoms. These individuals will be the penguin "parents." Give each individual in the second set a scent container lid. These individuals will be penguin "babies."

3 Have the penguin babies gather and mill about in the center of the room. The penguin parents (returning, theoretically, from foraging for food) then must find their own penguin baby with the same scent. Remind the penguin parents to keep their containers right-side-up so the cotton ball does not fall out.

4 Give the parents five minutes to move around and match scents. If the scents match, baby and parent should sit down.

5 At the end of the activity, determine how many babies survived by checking whether the codes on the container's lid and bottom match. Ask: How well did everyone "communicate"? Was anyone unsure about a scent or did scents overlap? If you practiced this activity a couple of times, would the group produce more successful matches? Collect the scent containers and store them for a future session, if you like.

Assessment

Ask children to design an experiment to test communication by scent or odor. How long do odors last? Do some travel farther than others? How quickly and how far do odors travel? (They might try this classic experiment: open a bottle of ammonia at the front of a room, and have individuals raise hands as the scent reaches them.)

Extension

Besides keeping family ties, scents help animals communicate in other ways. For example, ants lay down an odor trail between a food source and the nest so that others can find their way. Many animals urinate at strategic points to define the border of their own territory.

Using scented film canisters and working in two groups, set up an "odor trail" outdoors. One scent, such as vanilla, can mean "You're on the right track." Another scent, such as vinegar, can mean "Wrong way" or "Predator!" Each group can then try to follow and map out the other group's trail.

Credit

Adapted from "Smelly Signals," published by the National Science Foundation in its NSTW activities packet and prepared from resources of the Biological Sciences Curriculum Study (BSCS).

COMMUNICATIONS AT WORK

NOTE TO PARENTS, TEACHERS, & YOUTH LEADERS: Children whose interest is piqued by these activities may enjoy this profile of a scientist working in a related field. Science, engineering, and technology hold bright promise as potential career pathways in the 21st century.

Maydianne Andrade

Biologist
Cornell University
Ithaca, NY

Specialty Brown widows, Australian redbacks, and other deadly spiders.

Communication Connection Observes how male spiders communicate with much, much larger females during mating.

Just Part of the Job Paints color codes on the legs of deadly spiders.

Science Excitement At night in the Australian desert, Maydianne put on a miner's helmet and searched for female redback spiders about to eat their mates. The tiny males are all for it, she learned after careful observation. They even somersault their bodies closer to the female's mouth. Why? By promising themselves as a meal, Maydianne found, the males were allowed to fertilize more eggs.

Take It From Me "Science requires imagination. If you have a question, you can search for the answer in books or by asking your teachers or parents, but in the end you'll find that there are questions no one has answered yet. The excitement of science is in imagining a reasonable answer to your question, and then experimenting to see if that answer is true."

Connections

Copy • Distribute • Discuss

Community Link

Children can listen to animals almost anywhere—during a family picnic, a walk in the woods, or a trip to an urban park. Some tips:

- Stay very still and be patient.
- Cup each hand behind an ear to focus sounds.
- Make an "elephant ear"—a plastic bowl with a hole in the bottom. Put the hole up to either ear with the bowl pointing outward, like a satellite dish.
- Capture an insect in a cup. Cover the cup with taut waxed paper and secure it with a rubber band. Put the waxed paper up to the ear to hear loud insect sounds. Let the insect go when finished.

Resources

Animal Behavior Science Projects, by Nancy Woodard Cain (John Wiley; 1995). Twenty experiments, including decoding firefly patterns, interpreting the body language of wolves, and analyzing cricket songs.

Basic Projects in Wildlife Watching, by Sam Fadala (Stackpole Books; 1989). Twenty-five detailed projects for many habitats and types of wildlife that can help anyone see, listen, and even smell wildlife better.

Never Cry Wolf, a video based on the book written by Farley Mowat; Walt Disney Productions and Carol Ballard Films, 1983. This award-winning movie offers a compelling introduction to the study of animal communication.

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Get the Message?

Using Codes and Signals to Communicate

From pig Latin to Morse to binary, how and why do we use codes to get our messages across?

Overview

By sending distress signals from the *Titanic*, cracking coded song lyrics, and creating an egg-carton "binary decoder," children explore the many ways we use codes to communicate.

Skills

- Classifying
- Collecting and Organizing Data
- Interpreting
- Problem Solving
- Analyzing
- Communicating

Subject Areas

- Information Science
- Mathematics
- Language Arts

Estimated Time and Age Level

- *SOS Titanic*
  One 45-minute session (grades 7-12)
- *Code Masters Rule!*
  Two 45-minute sessions (grades 8-14)
- *Two Bits, Four Bits*
  Two 45-minute sessions (grades 8-14)

WEBS wires WAVES

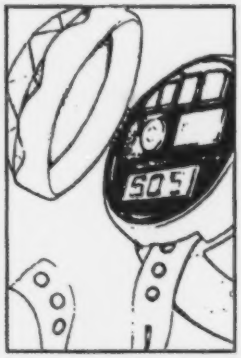
The Science & Technology of Communication

BACKGROUND

Talking Point On the night of April 14, 1912, an "unsinkable" ship named the *Titanic* was about to sink. Captain Edward Smith had underplayed ice warnings and the *Titanic* had struck a large iceberg. Now, 19 miles off the bow, frantic officers spotted the lights of the *Californian.* The communication challenge was clear: how could the sinking *Titanic* send an emergency message requesting help from the *Californian?*

One answer: a visual signal that could be seen for miles in the calm, clear night. The *Titanic* shot off white distress flares. The crew of the *Californian* saw them, but her captain interpreted the message casually. Using a lamp to make short and long flashes of light, he spelled out a query in Morse code. The *Titanic* didn't respond, so the captain went back to bed.

A second possibility: using new wireless radio technology, the *Titanic's* radio operator sent out one of the first SOS distress calls ever used at sea. Distant ships detected the signal and powered toward the *Titanic,* but they were too far away. The operator of the nearby *Californian* had turned off his radio to get some sleep. Her dire message unreceived by the one ship that counted, the *Titanic* sank, taking more than 1,500 lives with her.



Codes, But No Communicating The tragedy of the *Titanic* was this colossal failure of communication. Messages were sent but not received; when they were, the listeners misinterpreted or ignored them. The sinking of the *Titanic* pointed to the crucial role codes and signals can play—*if* they're understood by both sender and receiver.

Why so crucial? What are the reasons why we've come to depend so much on codes to communicate?

- **Distance** When distance is too great for sound to travel—including even the mighty *Titanic*'s horn—a flash of light or a simple radio signal can get the job done instead.
- **Simplicity** An SOS call is simple to send and receive. Simplicity is important for visual codes, too: cattle brands and international directional signs are two examples.
- **Secrecy** Codes and signals can hide a message from prying eyes and ears. The combination for a bicycle lock, for example, helps prevent the bike from being stolen.
- **Technology** Technology enables us to code and send enormous amounts of information from phone to phone or computer to computer.

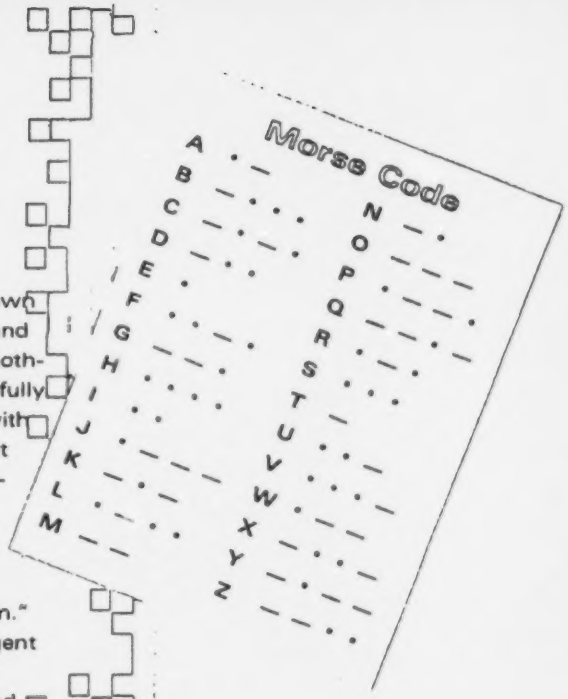
Codes, and the ways they are transmitted and received, take many forms. In the activities that follow, you and the youngsters with whom you're working will explore this topic by sending messages in Morse code, inventing different alphabet codes, and experimenting with the binary codes that lie at the heart of modern telecommunications.

BACKGROUND RESOURCES

Codes, Ciphers, and Other Secrets, by Karin N. Mango (Watts; 1988). Clear descriptions of many different codes and ideas for coding devices children can make.

SOS Titanic

The Code That "Missed the Boat"



ACTIVITY ONE

Overview
By encrypting, transmitting, receiving, and deciphering messages in Morse code, youngsters will take an important step in understanding how we use symbols, codes, and signals to communicate.

Time Frame
One 45-minute session

Suggested Age Level
Ages 7–12

Materials per Team
- Copy of Morse code alphabet (see box above)
- 1 penlight or flashlight
- 2 pencils and pads of paper

Preparation
- Make one copy per team of the Morse code alphabet. Write a different nautical message below the alphabet on each copy: ICEBERGS AHEAD, CLEAR SAILING, ROUGH SEAS, CIRCLING SHARKS, etc. Fold the papers in half to conceal the messages.

Procedure

1 Relate the story of the *Titanic* (page 2). Ask: how did the two captains attempt to communicate? What technologies and methods did they use? Why did communication fail?

2 Present Captain Smith's dilemma as a problem to solve. Create teams of "*Titanic* crew members" with two to four youngsters each. Hand each team a Morse code alphabet and penlight. Point out that both captains sent messages in Morse code—but one used light and the other used radio signals. Teams can choose either method: shining long or short flashes of light (representing the dashes and dots, respectively, in Morse code), or tapping out the signals with a pencil on a desk. Allow the youngsters, working as a group, to practice sending and receiving the messages on their alphabet sheets.

3 Have teams encode their own messages in Morse code and take turns sending them to another team until they are successfully decoded—and responded to with an "OK" or "REPEAT." Ask that this activity be done first without talking; that, after all, is the point of the exercise.

4 Challenge the teams to improve their "transmission." Ask them to write another urgent message—for example, NEED DOCTOR or LOST ENGINE—and send it as quickly as possible. Teams may find they work best if they assign roles to members: "receiver," "decoder," "encoder," "sender." Can they send a distress message and receive confirmation within, say, 30 seconds?

Assessment
Hold a Morse code relay race. Have three or four teams relay a secret message from one team to the next, racing against another group with an equal number of teams.

Code Masters Rule!

- Solve a Mystery
- Invent a Code
- Send a Message

Overview
Youngsters will crack an alphanumeric code to solve a historical riddle, and then create their own codes to send messages to each other.

Time Frame
Two 45-minute sessions

Suggested Age Level
Ages 8-14

Materials
- "History Mystery Song" (see *Challenge!* box, page 5)
- Paper and pencil for each youngster

Preparation
- Make one copy per team of the "History Mystery Song" (codes only—not the translation) or write the codes on a chalkboard or large poster board for everyone to consult.

A History Mystery Song

The following is a translation of the coded song lyrics on page 5.

Follow the drinking gourd! Follow the drinking gourd.

For the old man is awaiting for to carry you to freedom

If you follow the drinking gourd.

When the sun comes back, and the first quail calls,

Follow the drinking gourd.

For the old man is awaiting for to carry you to freedom

If you follow the drinking gourd.

(Code: A = 4, B = 5, C = 6, etc.)

Procedure

1 Introduce the activity by asking youngsters to recall sending messages in Morse code in Activity 1. In that instance, both sender and receiver knew the code that was being transmitted. In this activity, you will challenge them to "crack" a code themselves and solve a historical mystery.

2 Divide the group into an equal number of teams of approximately four children each. Ask each team to brainstorm a list of known codes. Next to each listed code, they should write how and where the code is used. Some examples: Morse code, pig Latin, bar codes, number codes to open locks, zip codes, area codes and telephone numbers, sign language, Braille, and state abbreviations. Ask: what do all of these codes have in common? *(A coded language stands in place of a message or piece of information.)*

3 Now ask each team to practice writing and sending a coded message to another team, using a simple letter/number substitution code: 1 for A, 2 for B, etc.

4 Tell youngsters they have become expert cryptologists—code makers and breakers—who have been assigned the difficult task of cracking a code concealing the meaning of an important pre-Civil War era song in American history. Challenge them to decode the words to the song—*and* decipher the secret meaning of those words. *(The song helped escaping slaves on the Underground Railroad find their way north by "following the drinking gourd"—the Big Dipper, which points to the North Star.)*

Present them with the coded lyrics for the song (see *Challenge!* box, page 5) and ask them to get started. If some teams have trouble coming up with ideas, remind them to recall where they want to end up: with letters spelling out words that make sense together. Their challenge is to find the code that matches each number with a particular letter. Suggest to teams that continue to have trouble that they write the alphabet in a column down the left side of a piece of paper, and try numbering each letter (1-A, 2-B, 3-C) and so on, experimenting with different numbers at the start of the alphabet. *(The correct code begins with 4 for A, then 5 for B, 6 for C, and so on.)*

5 Once the teams have deciphered the lyrics, ask for their suggestions regarding the secret message embedded within them. If every team is stumped, try giving them hints about the Underground Railroad or the use of the night sky for direction-finding.

6 Give each team the opportunity to create its own code. Remind them to look at the list of codes they brainstormed earlier for inspiration. Possibilities include:

- a derivation of pig Latin, which puts the consonant at the beginning of any word at the end and adds "ay," as in "ecret-say essage-may";
- inserting random spaces: "s ecr etmes sa ge";

- using peers' names in the same fashion as the alphabet code used by airline pilots (Alpha, Bravo, Charlie): "Shoshona Essie Curtis..." or
- doing a visual code, such as that used by baseball coaches to signal players at bat and on the field.

They should then encode a secret message or the lyrics of a favorite song, and give it to another team. Each team should try to decipher another team's code and then critique the code, giving suggestions for improvements.

Assessment

Have each child create a new code, explain how it works, and encode his or her own name.

Extension

Challenge individuals or teams to invent three new codes (or applications of existing codes) that *satisfy a need in everyday life.* For example: Can they come up with a special code for you to use to signal the group to quiet down? Or: a way for basketball or baseball players to use Morse code on the field? Or: a written code the whole group could "adopt" as its own method of secret communication?

Credit

Adapted from *Codes, Inc., A Middle School Mathematics Unit;* Institute for Research on Learning, 66 Willow Pl., Menlo Park, CA 94025-3601 (IRL; 1995). A disk and a mathematics curriculum combined, *Codes, Inc.* creates real-world coding problems for young cryptologists in grades 6–8 to solve. The disk features encoding and decoding tools. Some activities can be scaled down for upper elementary grades.

Copy • Distribute • Discuss

Challenge!

Break the code and translate this "History Mystery Song." Then try to guess the secret coded meaning of the words.

9-18-15-15-18-26 23-11-8 7-21-12-17-14-12-17-10
10-18-24-21-7

9-18-15-15-18-26 23-11-8 7-21-12-17-14-12-17-10
10-18-24-21-7

9-18-21 223-11-8 18-15-7 16-4-17 12-22
4-26-4-12-23-12-17-10 9-18-21 23-18 6-4-21-21-26
28-18-24 23-18 9-21-8-8-7-18-16

12-9 28-18-24 9-18-15-15-18-26 23-11-8
7-21-12-17-14-12-17-10 10-18-24-21-7

26-11-8-17 23-11-8 22-24-17 6-18-16-8-22
5-4-6-14 4-17-7 23-11-8 9-12-21-22-23
20-24-4-12-15 6-4-15-15-22

9-18-15-15-18-26 23-11-8 7-21-12-17-14-12-17-10
10-18-24-21-7

9-18-21 23-11-8 18-15-7 16-4-17 12-22
4-26-4-12-23-12-17-10 9-18-21 23-18 6-4-21-21-28
28-18-24 23-18 9-21-8-8-7-18-16

12-9 28-18-24 9-18-15-15-18-26 23-11-8
7-21-12-17-14-12-17-10 10-18-24-21-7

ACTIVITY THREE

Two Bits, Four Bits

Make a Binary Code Cracker

Overview
Using an egg-carton binary coding device, youngsters will discover how to translate Base 10 Arabic numbers into binary code—the basis for all computer languages and foundation of all digital communication.

Time Frame
Two 45-minute sessions

Suggested Age Level
Ages 8–14

Materials
- Egg cartons (one-fourth as many as there are children)
- 32 small, uniform "bits" (paper clips, raisins, marbles, etc.) per pair of children
- Small plastic bags
- Step-by-Step box (page 7; one copy per pair of children)

Preparation
- To make Binary Code Crackers, cut the egg cartons in half lengthwise. For each one, label the six cups *from left to right:* 32, 16, 8, 4, 2, 1. Place 32 bits in each bag; you'll need one bag and binary cracker per pair.

Credit
Anno's Hat Tricks, by Akihiro Nozaki (Philomel Books; 1985). This book offers charming math puzzles to help youngsters learn how to think in binary code.

Step-by-Step Answers
A. 1; B. 11; C. 111; D 1010; E. 1101; F. 10000; G. 10100; H. 11000; I. 11011; J. 11110; K. 101011

Procedure

1 Ask youngsters to pair off. Write examples of binary numbers such as 1101, 101, and 11001 on a pad or chalkboard. The first rule in deciphering a code is to look for patterns. Do children see any? Explain that a code with just two digits (or other symbols) is called a binary code; "bi" means "two."

2 Brainstorm other binary examples: lights flashing on or off, such as the *Californian*'s message to the *Titanic* (page 2); the dots and dashes of Morse code; a question that's answered either yes or no; and so on. Explain that computer language is also binary. The computer has switches that are either on ("1") or off ("0").

3 Ask: how can a code with just two digits (0 and 1) relay messages or represent numbers with lots of digits? Hand out a Binary Code Cracker and reproducible to each pair. Explain that this simple device will help them understand how to crack the binary code. Take the youngsters through the example, reminding them that when they write out the binary numbers, they can drop all of the zeros on the left. For example, 000011 becomes 11.

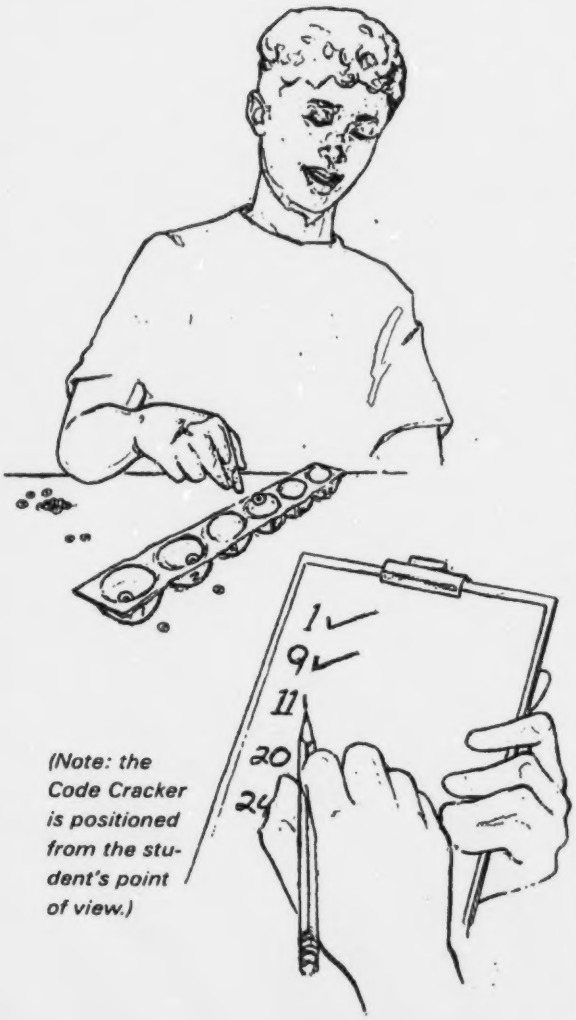
4 While pairs are completing the reproducible, solicit observations on patterns and strategies that develop. For example:

- Ask children to stop halfway through counting a number. Each bit is worth the number on its cup. Children will find that, if their coding is correct, the bits always total the target number.
- Ask: what's the highest number the Code Cracker can count? One bit in each cup equals 63 (the sum of the numbers on the cups). That number in binary code would read 111111. Ask again: if there were a seventh cup, what would 64 look like? (1000000)
- What number patterns do students notice? For example, what do the binary codes for the powers of 2 (2, 4, 8, 16, 32) have in common? They begin with 1 followed by all 0's (10, 100, 1000, etc.). The binary code is a base 2 counting system. Our base 10 system works the same way; the powers of 10 start with 1 followed by 0's (10, 100, 1,000).

Assessment
Test youngsters' understanding of the binary system by asking them to use their fingers as binary counters. Using your right hand, palm up, the thumb would represent the "1"s place; the forefinger represents the "2"s place; the middle finger is the "4"s place; and so on. To show the number 7, you would raise your thumb (1), forefinger (+2), and middle finger (+4) only. Ask them to test each other with numbers (for one hand) of up to 31. Older students can try both hands, which could express numbers up to 1,023. Now *that's* counting on your fingers!

Extensions

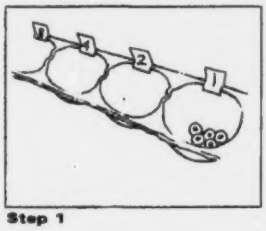
Challenge the group to come up with a way to use binary codes to represent letters in the alphabet, thereby enabling them to send worded messages encoded in binary numbers. Perhaps the most logical response would be to pair binary numbers with a corresponding letter in the alphabet: 1 for A, 10 for B, 11 for C, and so on. This "binary alphabet" is the basis for ASCII code ("American Standard for Computer Information Interchange"), which computer-users may recognize as the numeric code used to represent characters on many computers around the world. (See Booklet 5 for related activities.)



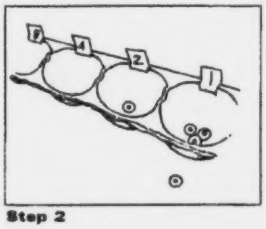
(Note: the Code Cracker is positioned from the student's point of view.)

Copy • Distribute • Discuss

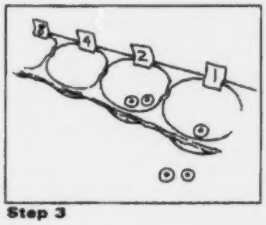
Step-by-Step



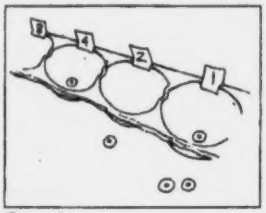
Step 1



Step 2



Step 3



Step 4

A Binary Code Cracker

Follow these directions to use your egg carton decoder to encode any number (up to 63) in binary code. Here's how to encode the number 5.

1. Place the target number of bits in cup 1.
2. Always work from right to left. If a cup has two or more bits, remove two bits. Drop one bit in the cup to the left, and set the other bit aside.
3. Keep moving bits until each cup has either 1 bit or 0 bits.
4. Add the numbers on the cups that contain 1 bit. In this example, 4 + 1 = 5. If your sum equals the target number, congratulations! You've coded the number! To express the number in binary code, write down a "0" for each empty cup and a "1" for each cup with a bit in it. The number 5 in binary code is 000101 or 101 for short.
5. Now, let's practice a little. Can you code the numbers below?

Number		Binary Number
A.	1	
B.	3	
C.	7	
D.	10	
E.	13	
F.	16	
G.	20	
H.	24	
I.	27	
J.	30	
K.	43	

COMMUNICATIONS AT WORK

NOTE TO PARENTS, TEACHERS, & YOUTH LEADERS: Children whose interest is piqued by these activities may enjoy this profile of a scientist working in a related field. Science, engineering, and technology hold bright promise as potential career pathways in the 21st century.

Barbara Szabo Doulas

Software Engineer
Tellabs Inc.
Lisle, IL

Specialty Writes programs (coded instructions) that tell a Titan 5500 computer system how to handle 688,128 telephone calls—all at once.

Just Part of the Job One spelling or syntax (grammar) mistake can crash the system. A missing "end command" (something like a period) is like telling the computer to head for a cliff and not to stop.

Science Excitement Avoiding system-crashing bugs is a thrill in itself. The Titan 5500 has more than 1,000,000 lines of code! Barbara and her team work with four languages, starting with English. They write messages in a computer code called C. C is translated into a more cryptic code called Assembler. Assembler is one step above binary code: row after row of 1s and 0s. Finding every bug in layers of code takes patience—and then some.

Take It From Me "Everywhere you go, you have to communicate. You communicate with people, but also with things—an ATM machine, for example. The more technology advances, the more ways of communicating you have to know. It all boils down to knowing what to say—and how to say it in many different ways."

Connections

Copy • Distribute • Discuss

Community Link

- A typical home, store, school, or place of business is filled with codes. As in the popular highway travel game of "I Spy," families can make a game of spotting codes anywhere they go. Some examples: movie ratings, zip codes, Social Security numbers, recipe ingredients, highway numbers, colored weather maps. Challenge your youngsters to work with their families to come up with the greatest number of codes.
- Most children love to learn American Sign Language: it's fun and can be beautiful to watch. Encourage the youngsters with whom you're working to learn basic signing. Most public libraries will have access to charts showing the sign language alphabet, or call the National Association of the Deaf at (301) 587-1788 for information and resources.

Resources

Loads of Codes and Secret Ciphers, by Paul B. Janeczko (MacMillan; 1984). How to recognize and crack codes from cattle brands to complicated matrices. Includes directions on how to make a simple telegraph device capable of sending SOS messages from one room to another.

Pass It On! All About Notes, From Secret Codes and Special Inks to Fancy Folds and Dead Man's Drops, by Sharon Bailly (Millbrook Press; 1995). Lots of activities and information on making paper, invisible ink, handwriting analysis, letter and number codes, and trade secrets of famous spies.

Codes and Ciphers: An A to Z of Covert Communication, by Fred B. Wrixon (Prentice Hall; 1992). How spies and other experts have tried to create "uncrackable" codes.

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http://www.nsf.gov/od/lpa/nstw/start.htm

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WEBS WIRES WAVES

Overview

Youngsters will learn what makes electromagnetic communication possible by constructing a rudimentary telephone and speaker out of ordinary materials.

Skills

- Recording Data
- Measuring
- Observing
- Inferring

Subject Areas

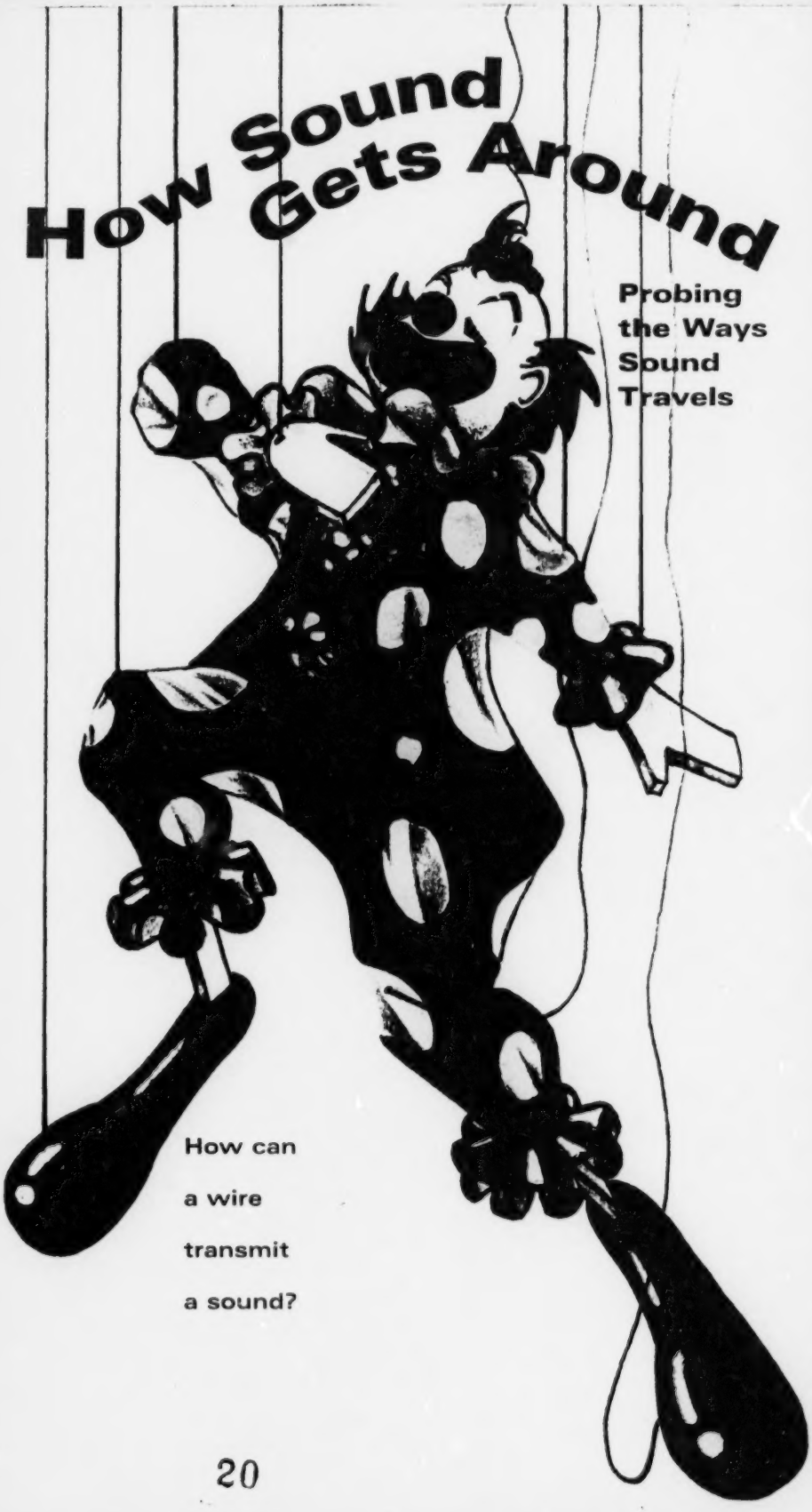
- Physics
- Technology

Estimated Time and Age Level

- *Good Vibrations*
  One 30 minute session
  (ages 7-11)
- *String It Along*
  One 40 minute session
  (ages 8-12)
- *Testing Ears*
  One 50 minute session
  (ages 11-14)

How Sound Gets Around

Probing the Ways Sound Travels



How can a wire transmit a sound?

WEBS wires WAVES

The Science & Technology of Communication

BACKGROUND

Talking Point One way to start a conversation about how sound travels is to imagine a place where it *cannot* travel: namely, in space. Sound waves (unlike radio waves, which are entirely different) can't travel in space because there is no medium—no substance, even air—through which sound vibrations can move. Thus, if two astronauts are floating apart in space and their helmet radios go on the blink, they can shout until they're hoarse and they still won't be able to hear one another.

However, astronauts do have a simple, low-tech backup for such a circumstance. They simply clunk their helmets against each other—and talk. Why would this work? Because the vibrations from their voices can pass from one helmet to the other.

Starting Simply The three activities presented here offer an inductive introduction to the dynamics of sound. They begin with *Good Vibrations,* which demonstrates with string and coat hangers that sound is caused by vibrating objects and that it needs a substance through which to move. *String It Along* presents an opportunity for a broad range of open-ended experiments that children can create and conduct using paper cup telephones. *Listen Up!* encourages students to create a speaker, working on the same principles as those of the earpiece in a telephone, that can actually play (albeit softly) a radio signal.

How They Work Each of the activities presents a different twist on one basic idea: that sound vibrations move in waves through substances. Both the coat hanger and the paper cup activities show that sound moves through solids (such as a string) and gases (such as the air we breathe). The reason is that wave energy is passed from atom to atom. The closer the atoms are to each other (and the stronger the wave), the more efficiently sound can travel. When the particles of a substance are densely packed, as in a solid such as string or copper wire, sound waves can generally move more quickly through them. When the particles of a substance are farther apart, as in a gas such as air, the waves take longer to travel through them.

The paper cup speaker from *Listen Up!* takes these ideas one step further by showing how sound vibrations, when turned into electromagnetic waves, can be turned back again into sound. The sound vibrations produced by a disc jockey's voice (for example) are converted by the microphone at the radio station into a series of electrical impulses. They travel from radio transmitter to radio, electrically prompting the magnet in the youngsters' paper cup speaker to move in a pattern similar to that of the original vibrations. The bottom of the cup then acts as a *diaphragm,* which vibrates the air outside of it back and forth in the same pattern as that of the original, recorded voice.

BACKGROUND RESOURCES

Eyewitness Books: Invention by Lionel Bender
New York: Knopf, 1991.

Hello! Hello! A Look Inside the Telephone. by Eve and Albert Stwertka. New York: Simon and Schuster, 1991.

ACTIVITY ONE

Good Vibrations

Make a Hanger Clanger

Overview
Children will learn how sound is made—and how it travels—by creating and observing a vibrating "coat hanger clanger."

Time Frame
Advance Preparation:
10 minutes
Activity: 30 minutes

Suggested Age Level
Ages 7 to 11

Materials per Child
- 1 metal coat hanger
- 1 60-cm (2-foot) piece of cotton string

Preparation
- Divide the group into pairs. Children will need chairs with backs against which to hit their hanger devices. They could also use the edge of a table.
- Cut one 60-cm (2-foot) piece of cotton string for each youngster. If you don't have enough metal hangers to go around, each team can share one hanger. However, since children will be holding one end of the string just inside their ears, they should change the string as they pass the device around.
- Set out the materials in a central location.

Procedure

1 Set the stage for the activity by asking the children what they think causes sound. They may suggest that sound is caused by talking, musical instruments, or electronic devices such as television sets. Write down their responses. After they do this activity, they can revise their ideas based on what they learn.

2 Have the youngsters make their "hanger clangers" by tying one end of a piece of string around the hook part of a hanger. Then ask them to hold the other end of the string *just inside one of their ears* and let the hanger swing freely against the back of a chair. The children will hear a ringing tone that will last for several seconds.

3 Now ask them again what they think causes sound. Give them time to confer with each other and to design new experiments to determine the cause and nature of the sound they hear, recording their observations after each experiment. For example, they might try:

- Examining the hanger after it hits against the desk or chair. What is it doing? *(Vibrating.)*
- Trying to alter the sound by changing the experiment through longer or shorter swings of the hanger or changing the hanger's shape.
- Grabbing the hanger just after it hits the chair. What happens? *(The hanger stops vibrating and the sound stops. By grabbing hold of the hanger, youngsters will be able to feel the vibrations as well as hear them.)*

4 Even if children don't use the word "vibrating," they should be able to conclude that sound has something to do with objects that move rapidly back and forth. Have them try out other vibrating sound makers, such as plucking a stretched rubber band. Ask them to propose and record some other ideas about what causes sound. They'll have a chance to build on these experiences and revise their hypotheses after the following two activities.

String It Along

Make a Low-Tech Telephone

Overview
Youngsters will explore how sound travels by conducting a range of experiments with paper cup telephones.

Time Frame
Advance Preparation: 20 minutes
Activity: One 40-minute session

Suggested Age Level
Ages 8 to 12

Materials per Team
- 2 paper cups
- 6 meters (20 feet) of waxed dental floss or colored fishing line
- 2 paper clips
- paper and pencil

Preparation
- Divide the group into teams of two children each. Make sure that the area where youngsters will test their phones is fairly quiet.
- Cut the floss or line into roughly 6-meter (20-foot) sections. If the children are younger than eight, you might want to provide assistance where appropriate as they assemble their paper cup telephones.
- Set out the materials in a central location.

Procedure

1 Set the stage for the activity by asking children how they think sound is traveling from your mouth to their ears. If (following from their experiences with Activity 1) they suggest that some kind of sound vibration is moving through the air, ask them to consider how sound vibrations could do this. Suggest that they explore how sound moves by conducting some simple experiments with a classic paper cup telephone.

2 To begin their experiments, children should create a "baseline" by standing a measured distance (six meters or 20 feet) from their partners and whispering into their cups. Can their partners distinguish the words? Ask them to keep track of their findings by recording their observations.

3 Children should begin making their telephones by using a pencil to poke a hole in the bottom of a cup. (They should stick the pencil right through.) Then they can tie one end of the floss or fishing line around a paper clip. The inner "loop" of the paper clip should then be inserted through the hole from the outside of the cup so that it is clipped securely to the circular bottom of the cup. (See diagram.) Have children repeat this process using the other end of the line and the second cup.

4 Now youngsters should return to their "baseline" distance. Each child can take turns placing the cup against one ear while his or her partner whispers into the cup at the other end of the line, always making sure that the line remains taut. Youngsters should now be able to hear their partners' voices resonating in the cups against their ears. Ask them to describe their results and to follow up with their own questions (and possible explanations) about what happened. For example:

- How are the sound vibrations getting from one cup to the other? *(They travel through the line.)*
- After the vibrations get to the cup at the end of the line, what might they be doing to the bottom of the cup? *(They cause it to vibrate, moving the air inside the cup in the same pattern that was created by the original sound.)*

5 Now challenge the youngsters to think of different experiments to try with their telephones. For example, they might find out whether or not their telephones will work when their lines are stretched through a closed door, or when their fingers are pressed against the bottom of the cup. Before they try an experiment, you might want to have them write down the procedure and the expected results. After trying the experiment, they can record their results and try to explain why or why not their prediction came true.

6 Bring students back to the original question. Ask them how they can use what they've learned with the paper cup telephone to explain how sound travels through air. If necessary, move the discussion along by giving children this hint:

- When people talk to each other, the space between them is not empty; it's filled with air. Air is a substance just as the dental floss or fishing line between the cups is a substance. What does this suggest about how sound travels? *(Sound needs a substance through which to travel.)* Relate the talking-in-space anecdote on page 2, if you like.

Assessment

To see how well your young scientists are understanding the properties of sound, challenge them to explore the properties of their paper cup telephones further by designing new experiments. If they get stuck, suggest the following:

- Try using your telephone with a sagging line between the cups. Does it work? Why or why not? *(It won't, because the pulling and pushing action of the diaphragm —the cup bottom—in response to your voice's sound waves will not transmit efficiently along a sagging line.)* Might it work if you used copper wire instead of fishing line or dental floss?
- Try using your telephone with someone holding the line in the middle. Does it work? If not, where are the vibrations going? *(It doesn't work because the vibrations are partly diverted by the person holding the line, weakening the signal that reaches the "receiving" paper cup.)*

Extensions

Older students could use their paper cup telephones to explore another important quality of sound—that it travels at different speeds through different media. All they'll need to do is replace the line between their cups with one that's three times as long. Then ask them to stand as far as the line will allow, again making sure that the line is taut. As one partner puts the cup to one ear, the other can shout while holding the cup on the other end of the line about six inches in front of his or her mouth. The "receiver" should hear the shout first through the ear covered by the telephone and then—an instant later—through the other ear.

Leave it to them to hypothesize why the shout reached one ear before the other. *(Sound travels faster through solids than through gases.)*

ACTIVITY THREE

Listen Up!

Speaker-in-a-Jiffy

Overview
Youngsters will create their own paper cup speaker and hook it up to a small radio.

Time Frame
Advance Preparation: 20 minutes
Activity: One 50-minute session

Suggested Age Level
Ages 11 to 14

Materials per Team
- 1 paper cup (4 oz. to 10 oz.)
- 1 small bar magnet (approx. 1 or 2 cm. wide and at least 3 cm. long; a bar-shaped stack of tiny magnets will also work)
- masking tape
- 2 ice cream sticks
- 3-by-5-inch index card
- scissors
- wire stripper (if available)
- 6 meters (20 feet) of thin enameled wire
- emery paper, 220 grit or finer (optional)

Materials for the Whole Group
- At least 1 small transistor radio with AM reception
- At least 1 monaural transistor radio ear plug (generally available from Radio Shack® or other electronics supply stores for abou $2)

Preparation
- Cut about 3 meters (10 feet) of thin enameled wire for each group. Using the scissors or the wire stripper (if one is available), scrape about 1 centimeter of coating off of the tips of each length of wire. If you want, ask youngsters to help by using emery paper to clean the ends of the wire (as well as assisting with the other Preparation steps).
- To enable youngsters to hook up their speakers to the radio, you'll need to prepare a simple wire "jack" or connector using the monaural ear plug. Use scissors to cut the cord at the end near the ear plug. Discard the ear plug. Using the scissors or wire stripper, if you have one, carefully strip away two centimeters of plastic coating from the cut end. *(Note: if an ear plug of this sort is not available, you can substitute an inexpensive pair of personal stereo headphones. You'll have to separate the wires and pull back the loose strands of copper wire you'll find beneath the outer plastic coating. You won't be needing them. Then carefully strip two centimeters of coating off of the remaining wire and your "jack" is complete.)* Make one jack for each radio. The more radios you can collect, the less waiting each team will have to do.
- Set up at least one radio to use for this activity. The best kind would be a small transistor radio that has a speaker and a headphone jack. You could substitute a personal radio that uses only headphones, but since such radios use very little power, youngsters will need to make their speakers very well to get them to work. Do not use an expensive stereo system. Large amplifiers can be damaged by paper cup speakers. However, any radio that has a compartment for batteries will work fine.
- Make one photocopy of the Step-by-Step box for each team.
- Set out the materials in a central location.

Procedure

1 Set the stage for the activity by asking youngsters to reprise lessons learned from the *String It Along* activity. Discuss how real telephones have small speakers inside them that change electricity into the sound vibrations that we all hear when talking with our friends. To discover exactly how these speakers work, youngsters are now going to make their own "speaker-in-a-jiffy."

2 Hand out the photocopies of the Step-by-Step box. If necessary, help youngsters assemble their speakers. Younger children might have trouble making neat coils, and that is critically important. To help them with this step, suggest that they keep wrapping the wire about ten times around the tube, and then pushing the coil down to one end. They'll find it easier to keep the coil neat if they keep pressure on the wire the entire time they're wrapping it.

3 After youngsters complete their speakers and (taking turns) hook them up to the radio, they

should be able to clearly—if somewhat faintly—hear radio signals coming through their speakers. If they don't, have them make sure the magnet is attached to the bottom of the cup and can move freely within the coil. They can also try pushing the ice cream sticks apart to immobilize the coil.

4 Challenge youngsters to relate what they've just seen (and heard) with what they discovered about sound vibrations in Activities 1 and 2. What is vibrating in the cup that produces sound? What's making it vibrate? They may be able to guess that the magnet is vibrating because it has been stimulated in some way by the radio. *(In short: the radio's electric current is generating its own magnetic field, which repels and attracts the magnet—i.e., makes it vibrate. The magnet taps the bottom of the cup and makes it vibrate as well, pushing the air on the other side in and out in the same pattern as the one the original sound wave produced at the radio station. See Booklet 4 for more information.)*

Copy • Distribute • Discuss

Step-by-Step

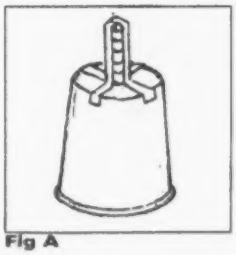


Fig A

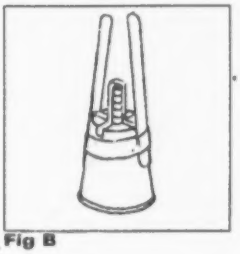


Fig B

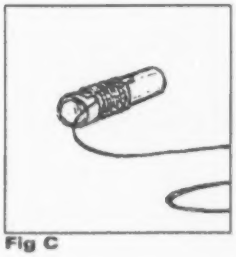


Fig C

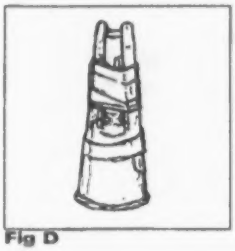


Fig D

Speaker-in-a-Jiffy

1 Turn the cup upside down. Loosely tape the magnet so that it sticks up from the center of the cup's bottom. (Fig A)

2 Tape the ice cream sticks on the outside of the cup as shown. (Fig B)

3 Cut a 5-centimeter strip from the index card. Roll and tape the strip into a tube with about a 2-centimeter diameter. (Fig C) The tube will have a thickness of about three card "layers." Make sure the tube fits easily around the magnet and can move freely up and down over it.

4 Cut a tiny slit in one end of the tube. Run the wire through the slit and wrap it around the tube about fifty times. Make sure the wire doesn't overlap. When you have a nice neat coil, put two or three pieces of tape over it to hold it in place.

5 Slide your tube-coil down over the magnet and tape it firmly to the ice cream sticks. It should not touch the bottom of the cup. Make sure the magnet remains independent within the tube, as it will need to vibrate inside of it. (Fig D)

6 When it's your team's turn, twist the end of your speaker's wire around the end of the copper wire connected to the headphone jack on the radio. Then tune in your favorite station, hold the open end of the paper cup to your ear—and listen to the results!

COMMUNICATIONS AT WORK

NOTE TO PARENTS, TEACHERS, & YOUTH LEADERS: Children whose interest is piqued by these activities may enjoy this profile of a scientist working in a related field. Science, engineering, and technology hold bright promise as potential career pathways in the 21st century.

Ted Darcie
Research Director
AT&T Labs
Murray Hill, NJ

Specialty *Fiber-optic systems*—a technological improvement on the copper wires that have carried all telephone transmissions until recently. Fiber optics use lasers to send images (such as television pictures), sounds (such as your voice), and computer data quickly around the world through tiny glass fibers.

All in a Day's Work Ted and his team spend half their time looking through microscopes at lasers the size of a grain of sand. They spend the rest of their time imagining a future in which televisions—using those tiny laser beams—can receive more than 1,000 channels.

Just Over the Horizon Soon, because of the work of Ted and his colleagues, we will all have handheld TVs and computers, we'll be able to see our friends as we talk on the videophone, and we'll order pizza (even with anchovies) over the television set.

Take It From Me "It's more important that you know how to learn about and understand new things, rather than just know about things already. Because the technologies and what we care about change very fast, you'll need to change very fast as well."

Connections

Copy • Distribute • Discuss

Community Link
How important is the telephone in our lives? Youngsters can explore this question by taking a survey of friends and family members. Suggest they start by designing an easy-to-use checklist that the survey participants can put near their telephones. Each time a participant uses the phone over the course of a week, he or she can use the checklist to record certain information: reason for the call, length of the conversation, category (friend? family? business?) of the other party.

After the week is up, children can collect the lists to collate and interpret the information they gathered. To help display the survey results, youngsters might want to use visual aids, such as pie charts and graphs. Ask: how would a similar chart look if it graphed survey results in a country with few telephones—or in your own community, say, fifty years ago? How did the youngsters' grandparents communicate with friends and family when *they* were children?

Resources
THE WAY THINGS WORK, by David Macauley (Houghton Mifflin, 1988). An in-depth illustrated guide that unravels the mystery behind many machines—from levels to lasers, cars to computers. Includes an informative section on telecommunications that explains telephone speakers, radio transmitters, and radio receivers.

GET THE MESSAGE: COMMUNICATIONS IN YOUR HIGH-TECH WORLD, by Gloria Skurzynski (Bradbury Press, 1993). An informative book with color photographs about the technology behind a simple telephone call. *GET THE MESSAGE* takes readers from the inside of their telephones to the world of cellular communications.

EXPLORING THE SOUND SPECTRUM, The Exploratorium (3601 Lyon St., San Francisco, CA 94123; phone: 800-359-9899), Spring 1994. A special issue on sound includes a poster that places animal sounds, machines, musical instruments, and natural phenomena such as thunderstorms on a sound frequency graph from 0 to 1 million hertz.

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Frequency Flyer

Exploring the Electromagnetic Spectrum

How is a radio wave different from a sound wave?

Overview

Youngsters will learn about radio communication and the electromagnetic spectrum by producing their own radio waves, and then learning about how they do it.

Skills

- Recording Data
- Measuring
- Observing
- Hypothesizing
- Using Models

Subject Areas

- Physics
- Technology

Estimated Time and Age Level

- *Making Waves*
  One 50 minute session
  (ages 10-14)
- *Seeing the Light*
  One 60 minute session
  (ages 10-14)
- *Tuning In*
  One 40 minute session
  (ages 8-14)

WEBS wires WAVES
The Science & Technology of Communication

BACKGROUND

Talking Point A little more than a century ago, at the ripe old age of 16, Guglielmo Marconi began to carry out scientific experiments in the top two rooms of his family's house near Bologna, Italy. The young student focused on the work of earlier scientists to create a practical device that could be used to send messages in code. The telegraph, of course, had already been in use for several decades by then. But Marconi's device could send messages *without* the use of wires: through thin air!

At first, Marconi simply sent messages across the two rooms of his upstairs laboratory. Then, with the help of his brother (who would wave a white flag to show he'd received a message), Marconi sent radio messages farther and farther away from the house. Finally, in 1895, Marconi sent a message over a hill and beyond eyeshot. He knew then that his invention—which involved sending an electric signal along an invisible radio wave—had virtually endless possibilities.

Starting With Questions The three activities presented here offer an inductive, hands-on introduction to radio waves and the electromagnetic spectrum. To begin, youngsters make a simple radio wave generator with a kitchen fork, a battery, and some wires. When they run one of the wires across the fork, they hear static on a nearby AM radio. What happened? Youngsters can make guesses, but only by forging ahead with the other activities will they be able to determine what's going on.

In the second activity, students create their own experiments to compare the characteristics of radio and light waves. These experiences can help you lead them towards a discussion of how light waves and radio waves are closely related; they're both part of what's called the *electromagnetic spectrum*. They simply have different wavelengths and frequencies, which are measured in hertz (meaning the number of waves per second that cross a certain point).

In the final activity, youngsters make a paper model of a radio tuner to help them conceptualize the connection between the numbers on a radio dial and the radio frequencies they represent.

How It Works When children make static on their AM radio in these first two activities, what they're doing is creating *electromagnetic radiation* by releasing energy from the battery. Part of that radiation is made of wavelengths that are picked up by the radio tuner in the form of static. Other parts of it are composed of other, shorter wavelengths that can be picked up by the youngsters' eyes as visible sparks of light. Still other parts of that radiation fly out invisibly through space in minute amounts as ultraviolet radiation, microwaves, X rays, and gamma rays. (See chart, page 5.)

BACKGROUND RESOURCES

Sound: More Than What You Hear, by Christopher Lampton (Enslow Publishers, 1992). General overview of sound and electromagnetic waves.

Sound: A Creative, Hands-On Approach to Science, by Wendy Baker (Macmillan Children's Book Group, 1993). Eighteen creative experiments.

Making Waves

Producing Electromagnetic Radiation

ACTIVITY ONE

Overview
Children will make and test a simple radio wave generator using ordinary household materials.

Time Frame
One 50-minute session

Suggested Age Level
Ages 10–14

Materials per Team
- 1 inexpensive transistor radio (must receive AM)
- (2) 25-centimeter lengths of insulated wire (18-24 AWG*)
- 1 metal fork
- Tape (masking or electrical)
- 1 "C" or "D" flashlight battery

*AWG is the standard gauge used to measure wire. Insulated, 18-24 AWG wire will be thin copper wire coated with plastic, and is available from electronics, hardware, or home supply stores.

Preparation
- Before starting the activity, ask youngsters to bring in small radios that can pick up AM stations *(along with flashlights, if you want, looking ahead to Activity 2)*. For this first activity, each team will need its own radio, fork, tape, and battery. Teams can share radios if they're scarce.
- Prepare two wire "leads" (lengths) for each team by using scissors to cut 25-centimeter lengths from a spool of wire and using a sharp knife or wire stripper to scrape about 1 centimeter of plastic coating from each end.

Procedure

1 Divide the group into teams of two or three. Set the stage for the activity by asking youngsters how they think radios work. Ask the children to record their ideas.

2 Introduce this activity by challenging each team to actually create its own radio wave. To begin, have each team assemble its "radio wave generator" by first securely taping the end of one length of wire to one end of the battery, and one end of the second wire to the other end of the battery. Then team members should wrap the other end of either one of the wires tightly around the handle of the fork, making sure that the bare copper is touching the handle.

3 Now ask each team to turn on its radio, switch it (if necessary) to the AM band, and turn the dial all the way in one direction so that all they hear is static. Holding the fork close to the radio, youngsters should stroke the bare end of the other wire lead across the fork's prongs. If they don't hear corresponding static on the radio, they should make sure the wires are securely attached to the battery and fork handle.

4 Once all of the groups have successfully generated radio waves (represented by the static), ask them to explain why they think the fork device affected the radio. Ask them to record their ideas. They'll have a chance to revise their theories after doing the next activity.

Assessment
You can use this introductory activity for baseline assessment. Have teams collaborate on written and illustrated explanations of how their fork device affects the radio. After finishing with Activity 3, you can have the same team members collaborate on a revised explanation of the same phenomenon. By comparing the two explanations, you can determine how much the youngsters have learned.

ACTIVITY TWO

Seeing the Light

Comparing the Properties of Light and Radio Waves

Overview
Children will create and implement tests to compare the characteristics of light and radio waves.

Time Frame
One 60-minute session

Suggested Age Level
Ages 10–14

Materials per Team
- Radio and radio wave generator from Activity 1
- Flashlight
- Metal tray or metal foil
- Books and other classroom materials
- Tape measure or meter sticks (Youngsters can also pace off distances to make measurements)
- Copy of the *"What If...?"* box (optional)

Preparation
- Each team of four youngsters will need a space several meters long to test how far radio waves from their radio wave generator can travel.
- Set out the trays, flashlights, and tape measures in a central location.

Procedure

1 Ask children to recall the questions that may have arisen in conducting Activity 1. (For example: "Why can we *hear* something happen when we strike the fork—but we don't *see* anything happen?") In this activity, they'll seek answers to some of those questions by comparing the properties of radio waves and light.

2 Divide the group into teams of two or three. Each team's task is to design and carry out at least three different experiments to compare and contrast the properties of light and radio waves. Remind students to be observant of even subtle effects that their experiments produce, and to use measurements whenever possible to help quantify the properties of light and radio waves.

3 If youngsters aren't sure where to start, suggest that they operate their radio wave generator fairly close to the radio (say, 20 centimeters) and then shine the flashlight on the radio from the same distance. Those observations can represent their "baseline." Then suggest that they vary the conditions of their experiment, trying different distances or inserting obstacles between "source" and "receiver." One way youngsters can then display their results is by creating a chart that both briefly describes their experiments and makes a side-by-side comparison of light and radio waves. (See *"What If...?"* box, page 5.) You can assist teams that appear to be struggling by giving them a copy of that box, if you like.

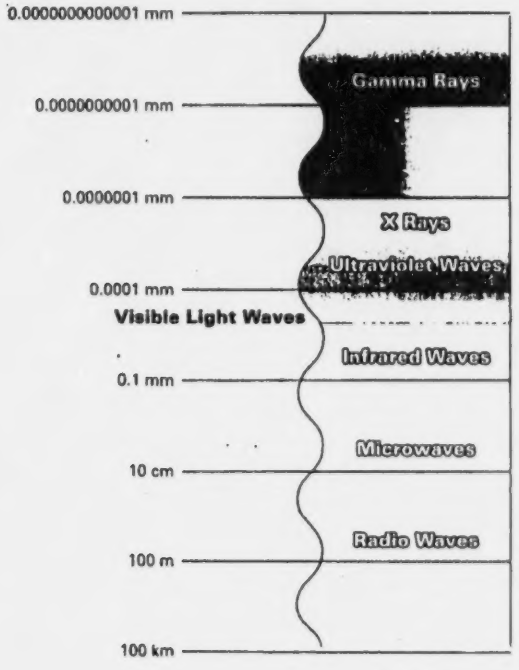
4 Up to now, the youngsters have been exploring the properties of radio waves by comparing them with light waves, but it probably hasn't occurred to them that light and radio waves are two very similar things. You can bring them closer to this realization with one more experiment.

Ask youngsters to once more make radio waves with their radio wave generator, but this time suggest that a member of each team cup his or her hands around the fork so that it's dark where the bare wire strikes it. *(You may want to darken the room first.)* Youngsters will see a spark of light when the wire strikes the fork and radio static is produced. What has happened?

- When the bare wire is stroked against the fork, it generates something called *electromagnetic radiation* by releasing electric energy from the battery. Ask: what might this tell you about the sound you hear on the radio and the light you see in your cupped hands? *(Radio and light waves are both types of electromagnetic radiation.)*

- Ask youngsters to picture the way water ripples outward when a pebble is thrown in a pond. Electromagnetic radiation travels through space in much the same way (though it doesn't require a medium in which to travel, as sound waves do). Some of the individual ripples are very short and some are much longer. Ask: what is the difference between light waves and radio waves? *(They have substantially different wavelengths. Light waves are very short; radio waves are longer. See chart, below.)*

The Electromagnetic Spectrum



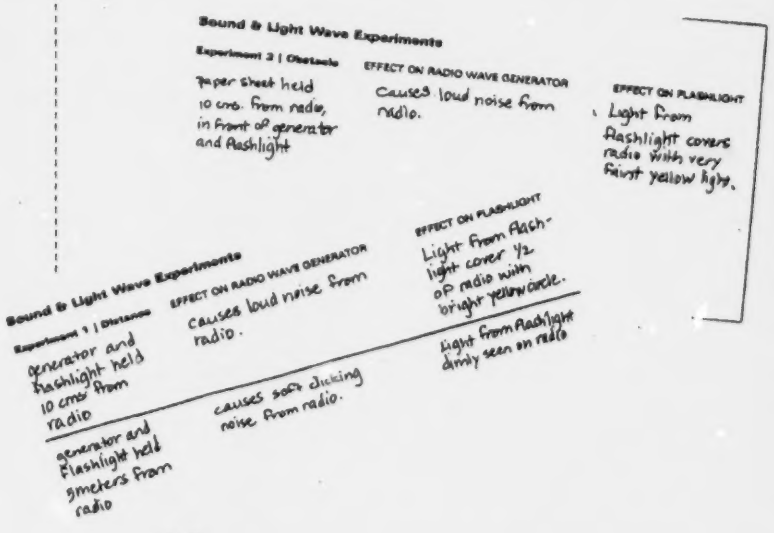
"What If...?"

Possible Explorations With Light and Radio Waves

- Explore how distance affects both light and radio waves. Start by creating a "baseline" by measuring a distance of 20 centimeters from the radio, striking the radio wave generator, and describing the results. Then shine the flashlight on the radio from the same distance and describe the results. Now slowly move the radio wave generator away from the radio until it no longer interferes with the radio. Measure the distance: how far can the radio waves you're generating travel and still be heard? Shine the light on the radio from that distance and describe the results.

- Explore how obstacles affect light and radio waves. Repeat the above experiment, placing a piece of paper in front of the generator and flashlight. Do the radio waves travel through the paper? Do the light waves? Try repeating the experiment, using a large book and the metal tray at a range of distances.

- Explore other variables. Get creative! Try exploring whether light and radio waves can travel through walls, trees, water (through a fish tank), around corners....


Sound & Light Wave Experiments
Experiment 3 | Obstacle
Paper sheet held 10 cms. from radio, in front of generator and flashlight
EFFECT ON RADIO WAVE GENERATOR
Causes loud noise from radio.
EFFECT ON FLASHLIGHT
Light from flashlight covers radio with very faint yellow light.
Sound & Light Wave Experiments
Experiment 1 | Distance
generator and flashlight held 10 cms from radio
EFFECT ON RADIO WAVE GENERATOR
Causes loud noise from radio.
EFFECT ON FLASHLIGHT
Light from flashlight cover ½ of radio with bright yellow circle.
generator and flashlight held 3 meters from radio
causes soft clicking noise from radio.
Light from flashlight dimly seen on radio

ACTIVITY THREE

Tuning In

Simulating a Radio Tuner

Overview

By making a paper-tube model of a radio tuner, children will simulate how radios pick up different stations broadcasting at different frequencies.

Time Frame

Advance Preparation: 10 minutes
Activity: One 40-minute session

Suggested Age Level

Ages 8-14

Materials per Team

- 2 sheets of paper
- Tape

Preparation

- Youngsters will need a place where there is some "white noise"—background noise such as the sound of cars moving by outside, wind blowing through trees, a whirling fan, or the hum of conversation. Chances are that youngsters will make enough noise talking to their partners for this activity to work in an otherwise quiet room.
- Set out the materials in a central location.

Procedure

1 Review with youngsters some of the properties of sound and radio waves—many of which they may recall from conducting Activities 1 and 2, along with the activities in Booklet 3. As the discussion proceeds, try to hit on these major points:

- Sound waves are a physical phenomenon caused by vibrations. *(To be more specific: when a guitar string—or a metal coat hanger—vibrates, it pushes nearby molecules of air back and forth, creating alternate spaces of crowded or thinned-out molecules. These alternating spaces create the sound waves.)*
- Radio waves, like light waves, are entirely different from sound waves. They are both forms of electromagnetic radiation that you can produce, for example, with a battery and fork.
- Electromagnetic radiation comes in different wavelengths, and the wavelength determines whether the radiation is light or radio. For older students, you can also discuss radiation of other wavelengths: microwaves, X-rays, etc. (See chart, page 5.)

Now ask youngsters about what they think the different numbers on a radio dial mean. Record their answers, and tell them that they will be making a simulation of a radio tuner that will help show how it works.

2 Divide the group into teams of two youngsters each. Have each team roll one sheet of paper into a tube and tape it. Then teams should roll the second sheet of paper over the tube and tape it as well, so that it can slide freely back and forth. Youngsters should hold one end of the tube over their ear while their partners slide the inner paper tube back and forth, shortening and lengthening the overall length of the tube. Ask them to describe what they hear. *(They'll hear a pitch inside the tube that gets higher when the tube is shorter and lower when the tube is longer.)*

3 After youngsters have time to experiment with their model radio tuner, ask questions to get them thinking about what they're hearing, and why the pitch they hear changes with the length of the tube. For example:

- In this experiment, are you hearing sound waves or radio waves? *(Sound waves; radio waves must be converted into sound waves in order to be heard.)*
- What sound do you hear when the tube against your ear is long? *(A low-pitched hum.)*
- What do you hear when the tube is shorter? *(A higher-pitched hum.)*
- Ask youngsters to recall from their Activity 2 discussions that radio waves travel in different lengths. Explain that sound vibrations behave the same way: some sounds have longer wavelengths, while other sounds have shorter wavelengths. Challenge teams to use their paper tuners

to hypothesize the connection between sound wavelength and pitch. *(The longer their tube, they'll discover, the lower the pitch. While sound waves of many lengths entered the tube, only those of a certain length related to the length of the tube will resonate—that is, reflect off of its walls in such a way that will make them grow bigger and therefore louder.)*

4 Once youngsters understand how their paper tuners work, ask them again what the numbers on a radio dial might mean. Give youngsters time to confer with their partners and agree on an explanation. Eventually, each team should come to the following conclusions:

- Waves (including sound waves and electromagnetic waves) come in many different lengths.
- The numbers on a radio dial are related to different-length radio waves.
- Radio tuners work by focusing on radio waves of one specific length. When you move the dial, you change the length of the radio wave that the radio picks up.

Assessment

If youngsters collaborated on written explanations of how their fork device affected the radio back in Activity 1, now is a good time to have them take another crack at it. Given what the teams have learned about radio waves by comparing them to light waves in Activity 2 and making a model of a radio tuner in Activity 3, ask them to review, expand, and (if necessary) correct their earlier explanation of the fork device.

Extensions

Youngsters can make the connection between their paper tuners, a real radio dial, and radio wavelengths come alive even more by creating their own numerical band of radio "stations." Have each team mark off their tuners with vertical lines every 5 centimeters (culminating at 40 centimeters for two 8-1/2-inch-long paper tubes). By sliding the inner sheet in and out, students can "tune in" to a certain wavelength of white noise. (See illustration.) Ask teams to share tuners and compare. Is the sound produced by one team's tuner when it's "tuned" to 30 centimeters identical to that produced by another team's tuner when it, too, is tuned to 30 centimeters? It should, provided that the white noise has remained constant as well. For fun, the youngsters might adopt a certain paper length as their own radio station, naming it after their initials.

COMMUNICATIONS AT WORK

NOTE TO PARENTS, TEACHERS, & YOUTH LEADERS: Children whose interest is piqued by these activities may enjoy this profile of a scientist working in a related field. Science, engineering, and technology hold bright promise as potential career pathways in the 21st century.

Fran Hart

Advanced Product Development Engineer, 3M
Minneapolis, MN

Specialty Among many other responsibilities, Fran helps design wireless telecommunication devices, such as electronic mailboxes that fit in your wallet and receive mail as you walk around. When you finally sit down, you can plug the mailbox into a computer and read your mail.

Job Challenge Fran needs to make sure that her telecommunication devices receive only certain electromagnetic waves. Unwanted electromagnetic waves can create havoc with the data.

Favorite Tools Three computers that solve huge math problems to calculate the strength of electromagnetic waves.

Glimpse into the Future Envision a world, Fran suggests, where you walk into your house with just one gizmo in your hand that you can use as a telephone, pager, TV remote control—even a garage door opener.

Take It From Me "Most engineers love what they do—*and* they love to talk about it. Whenever you happen to meet a scientist or engineer, don't be afraid to ask questions. You'll probably get an earfull!"

Connections

Copy • Distribute • Discuss

Community Link
How many radio wave generators are in the average home? Challenge all of your young researchers to find a way to count the devices at home that produce radio waves.

One possible method would be to carry a small, portable AM radio around the house and hold it in front of different objects to see if any radio waves are being emitted. It shouldn't take the children too long to find out that electronic appliances, lamps, light switches, and TV remote controls produce radio waves that can be plainly heard as interference.

After the children conduct their home survey, have the whole group compile a list of all the types of radio wave–producing items that were found.

Resources

Tuning In: The Sounds of Radio, by Eve and Albert Stwertka (J. Messner, 1992). A lively, illustrated approach to the basics of radio communication. This book contains many hands-on radio activities that can be used for further exploration.

Guglielmo Marconi, by Nina Morgan (Franklin Watts, 1991). The story of the discovery of the radio wave and the invention of the radio.

Everyday Things and How They Work, by Mary-Jane Wilkins (Franklin Watts, 1991). Where does electricity come from? How do radios work? Using colorful drawings and short explanations, this book explores common objects and how they work.

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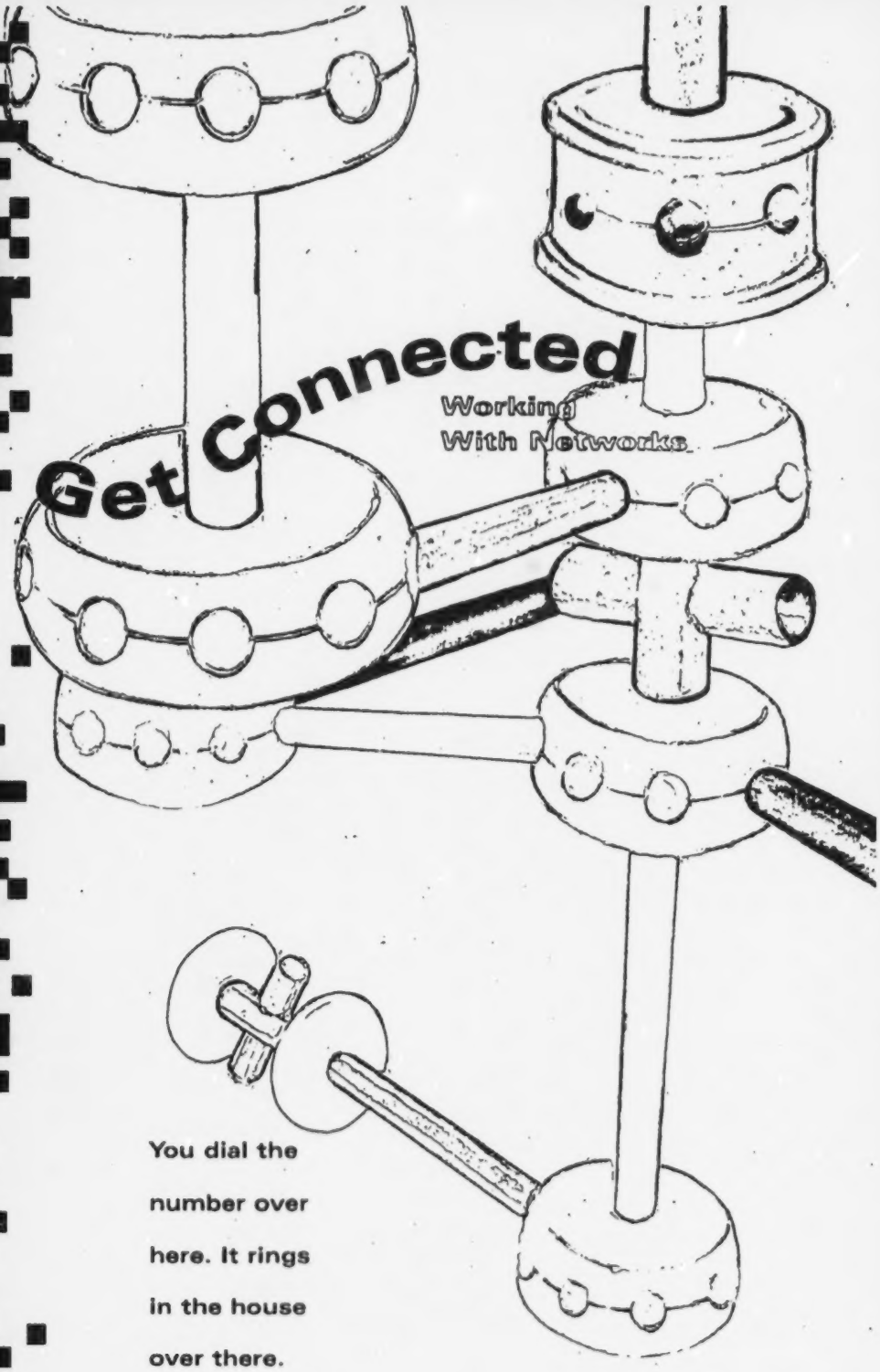
5 COMMUNICATING THROUGH NETWORKS

Overview

Skills

Subject Areas

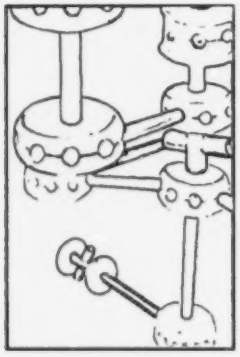
Estimated Time and Age Level



Get Connected

Working With Networks

You dial the number over here. It rings in the house over there. How?



BACKGROUND

Talking Point It's 1892 and automobile inventors in Europe and the United States are just starting to rev up their engines. But a lot of kinks remain to be worked out. In Iowa, William Morrison's electric car can travel just four miles before its batteries run out. Henry Ford in Michigan, the Duryea brothers in Massachusetts, and other inventors in Germany and France are tackling similarly daunting challenges on cars of their own design.

How can these inventors share their ideas, plans, dreams, and mistakes?

In 1892, it's difficult. Telegrams can carry a message—but only in one direction at a time. Drawings and diagrams must be sent by train and ship. Face-to-face conversations require weeks of travel. It's no wonder that several decades would pass before the auto would rule the road.

The Power of Networks If these inventors were doing their work today, they could be in daily—even hourly—contact. They could use computer networks to share diagrams and drawings; phone calls for updates; and teleconferencing for face-to-face contact. Imagine what they would say if they could see their modern-day counterparts at the company Henry Ford founded—including engineers in Europe, Asia, Australia, and the United States—using a dedicated high-speed network to sit down at their computer screens, thousands of miles apart, and examine a three-dimensional model of a prototype car. Imagine how much more quickly the automobile would have developed, had this kind of collaboration and communication been possible a century ago.

Telecommunications networks like the one used by Ford today, or that you use when you pick up a telephone, were hardly even dreamed of in the 1890s. These networks enable you to receive television and radio programs, send faxes, telegraph money, and communicate via computer with people all over the world.

Telecommunications networks depend on sophisticated technology to get messages through, but each network's basic elements are the same: *input, transport, switches,* and *output*. When you start a message on its way, you input it—by typing on a keyboard, say, or speaking into a phone. It is then carried by a form of *transport* (wire or wireless) to a *switch,* where it is held or redirected, and then *transported* to its destination for *output* to the recipient. This is true for any sort of message, whether it is "carried" by a mail carrier, a phone line, a radio wave, or any other form of transport.

BACKGROUND RESOURCES

Communication Technology, Today and Tomorrow by Mark Sanders, New York: Glencoe/McGraw Hill, 1991

Communication Technology by Robert Barden and Michael Hacker, Albany, NY: Delmar Publishers, 1990

ACTIVITY ONE

The Great Communi-Contraption

Build a Ping-Pong Network

Overview
Youngsters will design, build, and test a communications network model complete with multiple inputs and outputs, transports, and a central switching mechanism.

Time Frame
Preparation: Several days to collect materials
Activity: Three to six 45-minute sessions

Suggested Age Level
Ages 10–14

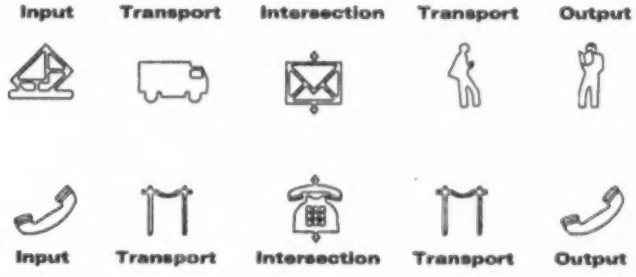
Materials Per Group
You'll need a space at least 20 by 10 feet for the model network, if it's a horizontal setup. Consider gym, auditorium, or stage space—or building "up" instead of "out."

- 6 to 12 white ping-pong balls (or equivalent)*
- Large (2-by-3-foot) pad of paper for brainstorming, if chalkboard isn't available
- One marker of any color
- Scissors
- Tape (masking or duct)
- Ball of string
- "Found" items for transporting ping-pong balls over distances (for example: mailing or wrapping paper tubes with open ends, milk cartons or jugs, cereal boxes, paper cups, cans, plastic pipe, cardboard)

Introduction: Common Links
Though they may not realize it, your young engineers already use a broad range of networks every day. Discussing these networks before launching this activity will help youngsters relate their ping-pong ball model with real-world experience.

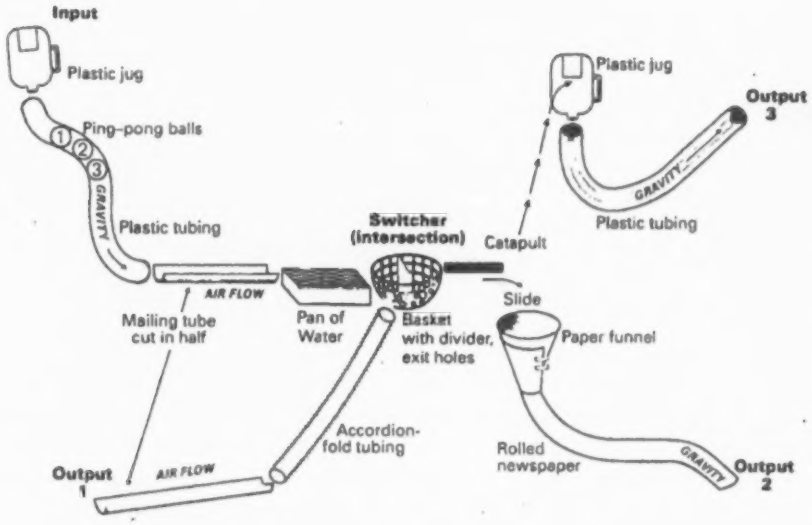
For example: Joe and Keisha want to invite their friends to a party. Joe mails invitations to his friends; Keisha makes phone calls to hers. The same basic network links speed the two messages—one written, one spoken—to their destinations.

Joe's Letter
Joe drops his stamped invitations in a mailbox *(input)*; from there they are carried by mail truck *(transport)* to a main post office *(switch)*, where they are sorted, and then carried by mail carrier *(transport)* to his friends' mailboxes *(output)*.



Keisha's Letter
Keisha picks up the phone and *inputs* the number each time she calls a friend. The call is *transported* over telephone wires to a central *switching* office, and from there it is *transported* to its final *output*, her friends' telephones.

Before moving into the next phase of this activity, challenge youngsters to describe more complex real-world networks. How would a portable phone, for example, complicate Keisha's example above?



At right: abstract, sample elements of a ping-pong network. Challenge youngsters to be resourceful and creative. For example: how might they propel a ping-pong ball across a pan filled with water?

Preparation

- Locate a place to store the collected materials while constructing the network.
- Gather materials that can be used to transport ping-pong balls. (Note: tubes of uniform width, especially wrapping paper tubes, are best, as they are less likely to cause blocking at intersections.)

*If colored ping-pong balls are available, make half of the balls white and half a second color. In this case, you won't need the marker.

Credit

"The Great Communi-Contraption" on pages 3–5 was adapted from *Kids In Touch*, an education program and competition sponsored by NYNEX and produced by Scholastic Inc.; 1993.

Procedure (Planning)

1 Introduce the idea of a communications network by discussing the basic elements of any communications link: input, transport, switch, output. (See *Background* and this activity's *Introduction* on page 3.) Challenge youngsters to describe three different networks—e.g., phone, mail, and e-mail—they might use to distribute invitations to a birthday party.

2 Ask the youngsters how they could create a self-contained model network that accomplishes the same things as the real networks they have just described. Can they design and construct a network model that will allow a message to travel from any one of several inputs, through a switch (or switches) to any one of several outputs? In their model, ping-pong balls (or the equivalent balls you've assembled) can represent the messages, while the gift wrap tubes and other items in their collection can represent the transports and the switches.

3 As a group, diagram possible ping-pong ball networks on the chalkboard or a large sheet of paper. Brainstorm the materials and forms of energy that might be used to transport ping-pong balls without touching them. Gravity, friction, flotation—even propulsion by catapult are possible means of transport. (See diagram, above.) Advise youngsters that their ping-pong balls must enter the switch and output in the order they were sent. After brainstorming a number of ideas, ask the group to decide on a single plan from which all of the teams can work together.

4 The group should decide which part of the network each team will build. The activity will work best if one team creates the switch(es) and each of the other teams creates one input, one output, and transports to and from the switch. *(Note: creating the network in sections makes it easier to store if it has to be dismantled between work sessions.)*

Procedure (Building)

1 Ask the input/output teams to create their input and output mechanisms and connect them with transports. Teams will then need to figure out how to connect their transports to the switch by consulting with the switch team.

2 Ask the switch team to create one or more switches that can collect incoming ping-pong balls from any input in the order in which they were sent, and direct them, in the same order, to any output. The switch team will need to interpret the coded addresses (explained below) for each incoming ping-pong ball "message" and send the message to the correct output. Although the switch team members may touch the ping-pong balls at the prototype stage, remind them that messages circulate through a real communications network *without* human intervention for each one. Can they design a switch that they can manipulate without physically touching the balls? *(One idea: create a switch mechanism that can be lowered, using a line strung through a pulley, to accept balls from the inputs and then raised to a higher level to send balls through different transports to the outputs.)*

Procedure (Testing)

1 Once the network itself is constructed, it's time to create meaningful messages out of the ping-pong balls. As a group, code the ping-pong balls by using the marker to add one color to half of the white balls (if necessary). Then ask each input/output team to create a coded address (using three balls, something like an area code) for its output. Then each team should create some actual coded messages, using one or more balls. One possible addressed message requiring seven balls might be:

- blue white blue = address for output 3
- blue blue white white = message: "Stand up!"

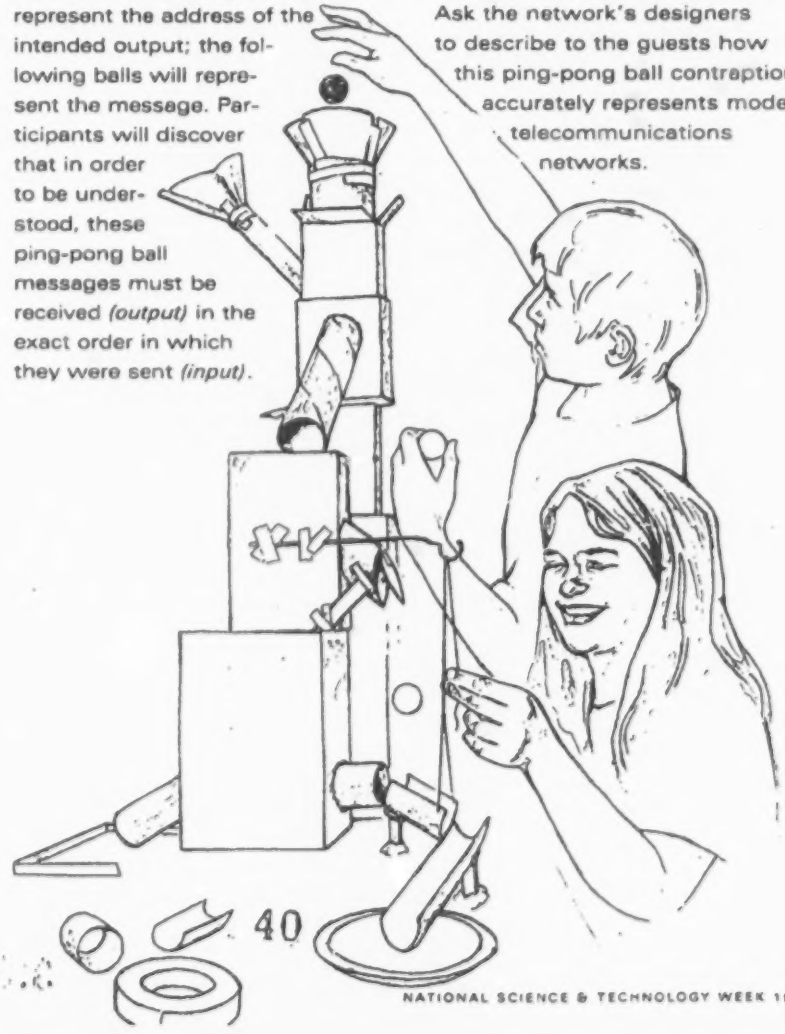
2 Make sure the input/output teams record the codes and their meanings on a master list that is visible to all participants. Note: It's especially easy to verify the receipt of messages requiring a physical response, such as "Stand up," "Jump," or "Clap hands." Teams may need to confer with each other to make sure addresses and messages do not overlap.

3 Test and refine the network by having teams address and send messages in code from each input to each output. The first three balls being input will represent the address of the intended output; the following balls will represent the message. Participants will discover that in order to be understood, these ping-pong ball messages must be received *(output)* in the exact order in which they were sent *(input)*.

Assessment

Ask the teams to create detailed "blueprints" of the mechanisms they've designed, and to amend their blueprints with new drawings, notes, and explanations as they refine their model. The blueprints will provide an accurate history of the project, and could provide a further form of assessment if, after disassembling the model, you ask teams to trade blueprints and put together each other's mechanisms from the plans.

You might also invite guests (other young people, teachers/mentors, parents—even local reporters or telecommunications company officials) to test the network, perhaps during NSTW'97 (April 20–26), by sending messages themselves. Ask the network's designers to describe to the guests how this ping-pong ball contraption accurately represents modern telecommunications networks.



ACTIVITY TWO

"Testing, Testing, 1-10-11..."

The Telecom Game

Overview
Youngsters will use their network model to send ping-pong ball messages encrypted in a version of ASCII code—the binary language at the heart of all digital communication.

Time Frame
Two 45-minute sessions

Suggested Age Level
Ages 10-14

Materials
- Ping-pong network from Activity 1
- One sheet of paper and pencil for each team of four
- "Binary Code" section from Booklet 2 of this NSTW packet

Preparation
- If you haven't conducted the binary code activity from Booklet 2 with this set of youngsters yet, you might consider doing so before initiating this activity. They'll use their understanding of binary numbering to encode and send binary messages through their ping-pong ball networks—just as messages are encoded and sent through telecommunications networks in the real world.
- Make sure the ping-pong network is set up and operational.

Procedure

1 Divide the group into the same teams from Activity 1. Ask each team to label one sheet of paper with the alphabet down the left margin. Next to each letter they should place a number: 1 for A, 2 for B, and so on.

2 Discuss with the group their experience with the ping-pong network from Activity 1. By the end of the activity, they should have been able to send messages that had been coded by the entire group: blue/blue/white/white for "Stand up," and so on. Explain that real telecommunications networks use a similar binary "language" that includes just two choices—blue or white, or "off" or "on," or 1 or 0—to send every message. Ask: how could they use their blue/white language to transmit a secret message (i.e., not one for which the group had already determined a special code) through the ping-pong ball network? The sheet of paper each team has begun to fill out serves as a hint that may lead them to the answer: translate the alphabet into binary code (perhaps using the number 27 to represent blanks between words).

3 Review binary numbering from Booklet 2 of this packet. Then challenge each team to translate the entire alphabet, using the numbers they have written next to each letter. Require that team members take turns doing the translating for each letter, helping each other as needed. Ask teams to check one another's translations for accuracy.

4 Ask one youngster to describe the classic game of Telephone (in which one person whispers a message into the ear of another, who then whispers it to another, and so on in a circle until the originator receives the message again—in correct or somewhat mutated form). Invite the group to play a more sophisticated form of Telephone called "Telecom," using their binary code tables and the ping-pong network.

5 Ask the "switch" team from Activity 1 to come up with a top-secret message no more than two or three words long (e.g., "Chill Out" or "Science Is Here"). You may want to review the message for appropriateness. The switch team should translate the message into binary numbers, with your assistance if necessary. (Note: they'll need to use the full five-digit binary number to represent each letter—i.e., "00001" for the letter A—so that receiving teams will know where one letter stops and the next one begins.)

6 The switch team should then originate the message by sending it into the network through any input mechanism it chooses. The switch team should route the message through its central switch(es) to the output created by the team that created that input (call it Team #1). As soon as that team begins receiving the message, it should translate the letters (silently!) one at a time, and then send each letter back into the network through its input mechanism.

The switch team should route the letters toward the output of a different team (call it Team #2). That team should translate and then send each letter back into the network through its own input mechanism, to be routed by the switch team to the output of Team #3, and so on until every team has received the message. (The last team in line should ask the switch team to route its letters back to the input mechanism of Team #1.) The message will almost certainly require more letters than the number of ping-pong balls you have available. Consequently, balls will need to "cycle" through the network several times before the message is completely transmitted.

7 When the last letter has been sent, ask each team to write the complete message (along with its team number) on a sheet of paper and submit it to the switch team. The switch team can then examine the results, determining how the network and the translators performed and where any communication trouble—if there was any—arose. Discuss the results with the entire group. If the message did not go through to each team correctly, try it again if time permits.

Assessment

Challenge youngsters to translate their own names and a party invitation phrase (i.e., "You're invited" or "Come to our party") into binary code and write the coded name and phrase on a blank sheet of paper. Collect and mix up all of the papers and then redistribute them. Then ask them to translate the messages they now hold and, once they're translated, deliver it to the addressees. Once the party invitations have been delivered, every youngster should diagram right on the invitation the network sequence (input-transport-switch-transport-switch-transport-output) that just took place. Finally: have that party to celebrate all of this new knowledge!

Extensions

Challenge older children to develop other ways to model binary communication. For example: how could one team translate and send a new message to another team by using a flashlight? ("On" might represent "0"; "Off" might represent "1.") Explain that in doing so, they are modeling the way new, more efficient fiber optic cable works as a transport, replacing older copper wire. Younger children might play the classic Telephone game, explaining who in the game is acting as Input, who as Transport, and who as Output.

COMMUNICATIONS AT WORK

NOTE TO PARENTS, TEACHERS, & YOUTH LEADERS: Children whose interest is piqued by these activities may enjoy this profile of a scientist working in a related field. Science, engineering, and technology hold bright promise as potential career pathways in the 21st century.

Aaron Dagen

Engineer NYNEX
Science & Technology, Inc.
White Plains, NY

Specialty Helping to develop wireless networks.

Just Part of the Job Aaron's job involves testing new services, analyzing the results, and discussing them with colleagues, customers, and others. He uses a sophisticated computer model to simulate networks and find out how to make them work together with other networks.

Big Goal Providing digital cable TV service over the air, using microwaves. If his team succeeds, NYNEX (soon to merge with Bell Atlantic) will be able to offer 200 channels—without a cable wire in sight.

Big Satisfaction When hard work pays off, and a new service he's worked to develop starts being used by the company's customers.

Take It From Me "Telecommunications is a constantly evolving and changing field. It offers a broad range of opportunities involving computers, voice technology, electrical engineering, mathematics, programming, and experimental design. Sound interesting? Then work hard. Hone your skills. You're someone with a future in telecommunications engineering."

Connections

Copy • Distribute • Discuss

Community Link
Networks touch our lives in many forms. Personal networks of family and friends sustain us in good times and bad; telephone, television, radio, and postal networks keep us connected with the world.

- **Who's Who in Your Network?** Chart each family member's personal network of friends. How does each family member communicate with the people in his or her network? Do those in each network communicate with each other? How does a personal network expand?
- **Making Connections** List the communication networks with which your family interacts regularly. These might include the postal service, telephone, fax, computer, television (broadcast or cable), or radio. Discuss how the basic communication link—input, transport, switch, and output—works with each network. In what ways does each example differ from the others?

Resources

How Science Works, by Judith Hann (Reader's Digest Association, 1993). Step-by-Step experiments (regarding sound, telephones, and radios) for parents and children to do together.

Communications, by Nigel Hawkes (Henry Holt & Company: Twenty-First Century Books, 1994). Short explanations of fiber optic networks, virtual reality, and other modern communication technologies with large color photos and drawings.

Get the Message: Telecommunications in Your High-Tech World, by Gloria Skurzynski (Macmillan Children's Book Group: Bradbury Press, 1993). What technology does it take to make a phone connection, send a fax, or pick up a satellite signal? An illustrated look at the answers to these and other questions.

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World Wide Web
http://www.nsf.gov/od/lpa/nstw/start.htm

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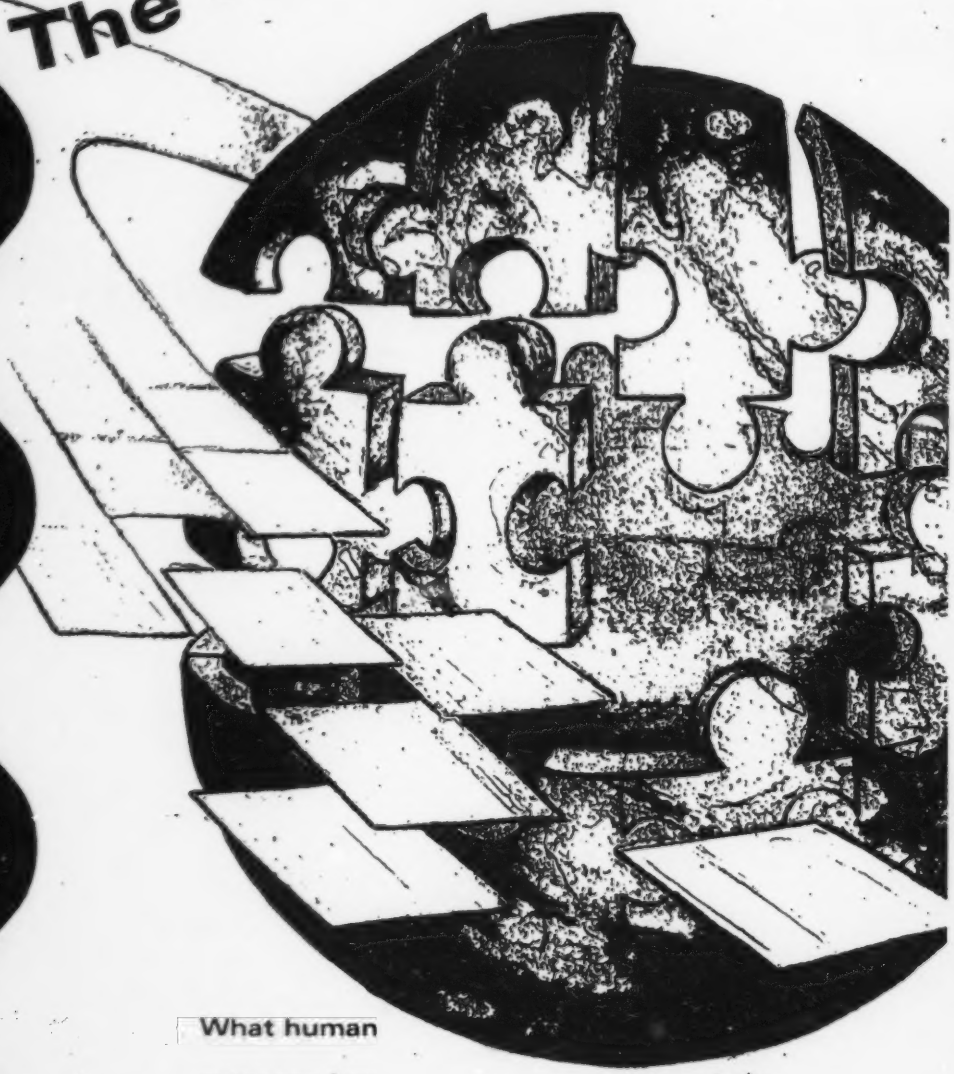
The Sky's No Limit

Decoding Images From Space



Overview

Skills

Subject Areas

Estimated Time and Age Level

What human message has traveled farther than any other?

WEBS wires WAVES
The Science & Technology of Communication

BACKGROUND

Talking Point Communicating with distant civilizations has been a staple of science fiction thrillers for many decades, but a little more than 20 years ago, scientists used the Arecibo Radio Telescope in Puerto Rico to attempt to do just that. The images to the right represent the radio message they sent toward a cluster of stars in a distant part of our Milky Way galaxy. Among other things, the images represent:

- the numerals 0 through 9 using a binary counting system;
- a schematic drawing of a human; and
- a schematic drawing of the solar system, with the third planet (Earth) being of special interest because it is out of line.

In all likelihood, the Arecibo message is the answer to the question posed on the cover of this booklet. It will reach its destination in 25,000 years.

Radios and Light Bulbs As was mentioned in Booklet 4 of this NSTW packet, radio waves like those carrying the Arecibo message are a form of electromagnetic radiation, much like the light waves that come from the bulb in a desk lamp. We routinely think of radio waves as carriers of Top 40 songs and disk jockey chatter to radio receivers. But radio waves are also used to send *two-dimensional* pictures—such as television shows, or the Arecibo schematic of a human figure, or the beautiful images we see from the Hubble Space Telescope. How is this possible?

The answer is that the image is not transmitted in two dimensions at all. Before it is transmitted along a radio wave, a television or Hubble image is divided into a long line of many little squares, called dots or *pixels*. When the television receiver picks up this information transmitted by the radio wave, it transfers the information, one pixel at a time, across the front of the television screen. By moving quickly across the lines and down the screen—in much the same way that we read type—a complete two-dimensional image is produced. The pixels are so small that a person's eye cannot pick out the transition from one pixel to the next. A typical television shoots an image composed of thousands of pixels across its screen 30 times per second.

Dot to Dot The first activity in this booklet offers youngsters a chance to experience firsthand how a pixelated image is produced. The simulated message from a distant civilization in Activity 2 will encourage them to work together at the frontiers of science to analyze what would be a dramatic communication from space.

BACKGROUND RESOURCES

Life in the Universe Series, created by the SETI Institute, available from Teacher Ideas Press, Englewood, CO. For grades 4–8; a search for clues to the possible existence of life beyond our solar system.

"Newton's Apple," Tenth Anniversary Show (#1001; often available through local PBS stations). Good information on pixel technology.

Astro-Adventures: An Activity-Based Astronomy Curriculum, by Dennis Schatz and Doug Cooper (Pacific Science Center; 1994). See credit, page 6.

ACTIVITY ONE

Pixel Me This

How We Receive Images Through the Air

Overview
By simulating pixel imagery, youngsters will discover how we receive television images through the air—and Hubble Space Telescope images from space.

Time Frame
Preparation: 30 minutes
Teacher-Directed Activity: 45 minutes
Student-Directed Activity: 45 minutes

Suggested Age Level
Ages 8–12

Materials
- Portable radio
- SPACE SHUTTLE, MISSION CONTROL and HUBBLE SPACE TELESCOPE signs (see *Preparation*)
- Crumpled balls of paper with words on them (see *Preparation*)
- Half-sheet of 1/2-inch-grid graph paper for each child
- Supply of small colored candies, such as M&Ms® or jelly beans, or small balls of colored paper (see *Preparation* for colors required)
- Crayons or colored pencils of colors matching the candies or paper balls
- Overhead transparency of the apple images from page 4 (or images can be passed around)

M&M is a trademark of the Mars Corporation.

Preparation
- Make a sign reading SPACE SHUTTLE that can hang around a person's neck. Make similar signs that read MISSION CONTROL and HUBBLE SPACE TELESCOPE.
- Place each word in the following statement on separate 4-1/4-inch by 5-1/2-inch pieces of paper: "Roger, Houston. We copy your message and are ready for reentry." Crumple each piece of paper into a ball.
- Select candies (or prepare balls of colored paper) and arrange them so you have the following colors in this order:

G	R	B	BL	Y	B	G	Y	R	BL	O
Y	G	B	R	O	B	BL	O	B	R	R
R	O	B	Y	G	B	R	Y	O	Y	G
Y	BL	B	B	B	B	BL	R	B	R	O
R	G	B	G	Y	B	O	O	B	BL	G
O	BL	B	O	R	B	G	BL	B	BL	Y
Y	Y	B	BL	Y	B	R	Y	B	Y	R

(Code: BL = blue, R = red, B = brown, Y = yellow, O = orange, G = green)

- Prepare the half-sheets of 1/2-inch-grid graph paper. Make a box on each sheet that is exactly 11 squares wide and 7 squares high. Label the columns (1 through 11 across the top) and rows (A through G down the left side). These will serve as the youngsters' "Space Image Grids."

25 x 25 pixels . **50 x 50 pixels** **200 x 200 pixels**

Procedure (Introduction)

1 Turn on a portable radio and scan through the stations. Ask how youngsters think the words and music travel from the radio station to the radio. Ask them to recall what they learned from activities in Booklets 3 and 4, if you conducted them, regarding radio transmission.

2 Now ask youngsters to imagine how a radio message might be transmitted from space. To give a more concrete and visual idea of what is happening, put the SPACE SHUTTLE sign around your neck, and ask one child to stand ten feet away with the MISSION CONTROL sign around his or her neck. Ask the group to think of the crumpled balls of paper with words on them as radio waves being transmitted from the Space Shuttle to Mission Control in Houston. Throw the balls one at a time (in their correct order) so that "Mission Control" can un-crumple each ball and read the words being sent. Reinforce the concept that messages from space come as small bits of information, one after the other, on radio waves. If time permits or the concept needs more reinforcement, have pairs of students create messages to transmit between each other.

Procedure (Main Activity)

1 Once students understand how this word message was transmitted, ask them how they think a two-dimensional image might be transmitted, such as a TV picture or one of the astronomical images observed by the Hubble Space Telescope. List these ideas.

2 Introduce the idea that a photograph can be divided into a number of small squares by showing the overhead projection of the three apple images shown above (or pass around the images themselves). Use them to explain how images are transmitted one square at a time. Introduce the term "pixel" to replace "square."

3 Give every student a Space Image Grid and explain that they will be acting as receivers, decoding an image from the Hubble Space Telescope. Ask them to get out the crayons or colored pencils. Put the HUBBLE SPACE TELESCOPE sign around your neck, and ask for a volunteer to wear the MISSION CONTROL sign. Toss the candies, or colored balls of paper, to "Mission Control" in the order provided under *Preparation*. "Mission Control should call out the color of each candy as it is received. The rest of the group should color each pixel with the appropriate color starting at the top left and going across to the right.

Periodically stop and make sure all students are working on the same pixel, using the column numbers. Ask if they have any guesses as to the image being "transmitted." List their ideas on a chalkboard or large pad, and then proceed until the entire image is produced. The image they should have by the end is the word "Hi," as shown in the illustration on page 3.

Assessment

Have pairs of students create images, coding long strings of colored "pixels," and ask them to send these messages to each other to assess how well they understand the concept.

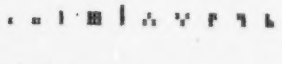
Extensions

Older students can experiment further by making the pixel size smaller and sending more complicated images. Graph paper with a smaller grid size works well for this activity. Motivated youngsters can take an existing image and divide it into pixels, and then devise a color and brightness scale to use in transmitting the image to another person. (Try photocopying small-grid graph paper onto a transparency for help in the pixelating process.)

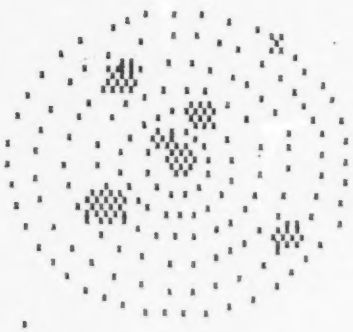
Academy of Galactic Communications Research

A Message From Space

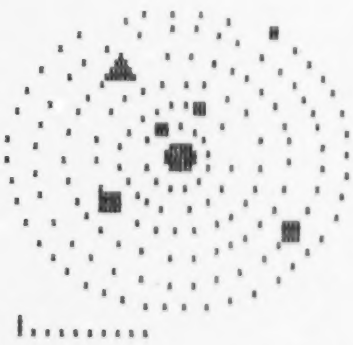
(A reproducible for Activity 2. See pages 6-7.)



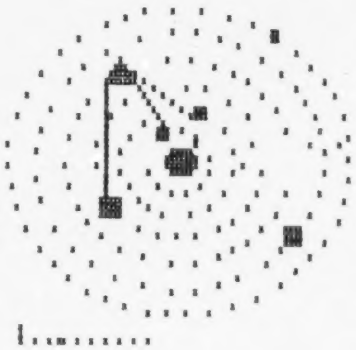
△ 1



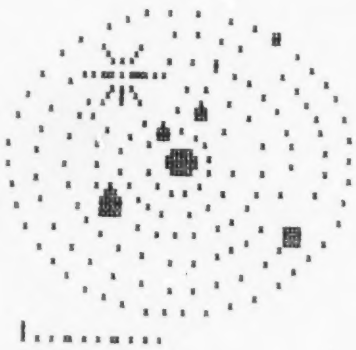
△ 2



△ 3



△ 4



△ 5

△ 6

ACTIVITY TWO

Reading You Loud and Clear

Interpreting a Simulated Message From Space

Overview
Teams will analyze and interpret a simulated message from a civilization on a planet orbiting a distant star and develop a return message.

Time Frame
Preparation and Introduction:
20 minutes
Group Directed Activity:
Two 45-minute sessions
Oral Presentations:
One 45-minute session

Suggested Age Level
Ages 10–14

Materials per Team
- "A Message From Space" diagram (page 5)
- Envelope
- Graph paper

Preparation
- Copy enough "A Message From Space" diagrams to have one per team of three or four youngsters.
- Fold copies of the message into envelopes addressed to each team from the imaginary Academy of Galactic Communications Research.

Credit
This activity was adapted from *Astro-Adventures: An Activity-Based Astronomy Curriculum* by Dennis Schatz and Doug Cooper, © 1994 Pacific Science Center (and available at 206-443-2001). *Astro-Adventures* is intended for use with students in grades 4–8. The "Message From Space" is based on a simulated message © 1976, 1992 by the Regents of the University of California. Used by permission of the Lawrence Hall of Science, University of California.

Procedure

1 Ask youngsters to examine the Arecibo radio message on page 2 of this booklet and discuss its messages. Then divulge that they have been asked by the Academy of Galactic Communications Research to analyze a radio message just received from what is thought to be a distant, intelligent civilization.

2 Divide the group into teams and distribute the envelopes with "A Message From Space" (see page 5) to each team, noting that this message was received as a series of images similar to the one they analyzed in Activity 1. It arrived at the radio telescope (receiver) as a long string of "X"s and "Blanks," and scientists at the academy realized it could be arranged into the images they see here. Now, however, they're stumped and need help. Ask each team to work together to decode the message, using your own knowledge of the given interpretation (see box, page 7) to help any struggling teams "jump-start" their own analysis.

3 During the second 45-minute session (perhaps a day or two after the first, to allow for independent thinking), ask the teams to finish their interpretations and prepare a group presentation.

4 At the final session, ask teams to share their interpretation of the message. With the whole group, discuss and debate the various ideas, including the

academy's interpretation if you want to use it. *(Remember, a real message from space will not arrive with its own "correct" interpretation. Consider keeping the provided interpretation under wraps, which would allow you to emphasize that youngsters are operating just as scientists do—where no definitive answers are provided.)* After the activity has been completed, you might suggest that the simulated message was only a test being conducted by the academy. Youngsters should realize that we have not knowingly received such a message from space—yet.

Assessment
Have the students plan a return radio message using the graph paper. Each square is a pixel that can either be a "Blank" or an "X." As youngsters plan their return messages, ask them to consider:
- how the return message might build on information that we and the distant civilization share, based on its message to us; and
- what aspects of our culture should be conveyed. Have each team transmit its message (after converting it to a long string of "X"s and "Blanks") to another team to interpret.

One Possible Interpretation of the Space Message

These suggested interpretations of the simulated message from space (see page 5) correlate with the numbered arrows in the reduced versions shown at right.

1 The numerals 0 through 9.

2 A schematic drawing showing the distant civilization's planetary system, with the time "Zero" shown at bottom.

3 A schematic drawing showing that life has formed on the fourth planet from the central star. The numerical symbols at the bottom translate to 4,000,000,000 time units from the first illustration of the simulated message. The unit of time is unknown; it could be years, decades, or a period used by the distant civilization which we're unable to define.

4 A schematic drawing showing that the three inner planets were colonized. Some youngsters may interpret this to mean that the civilizations on the other three planets destroyed the fourth planet. Either interpretation is reasonable, although the fact that the three inner planets have formed into triangles in Image 5 probably gives the colonization interpretation the greatest weight. A period of 4,001,000,000 time units has passed since the beginning.

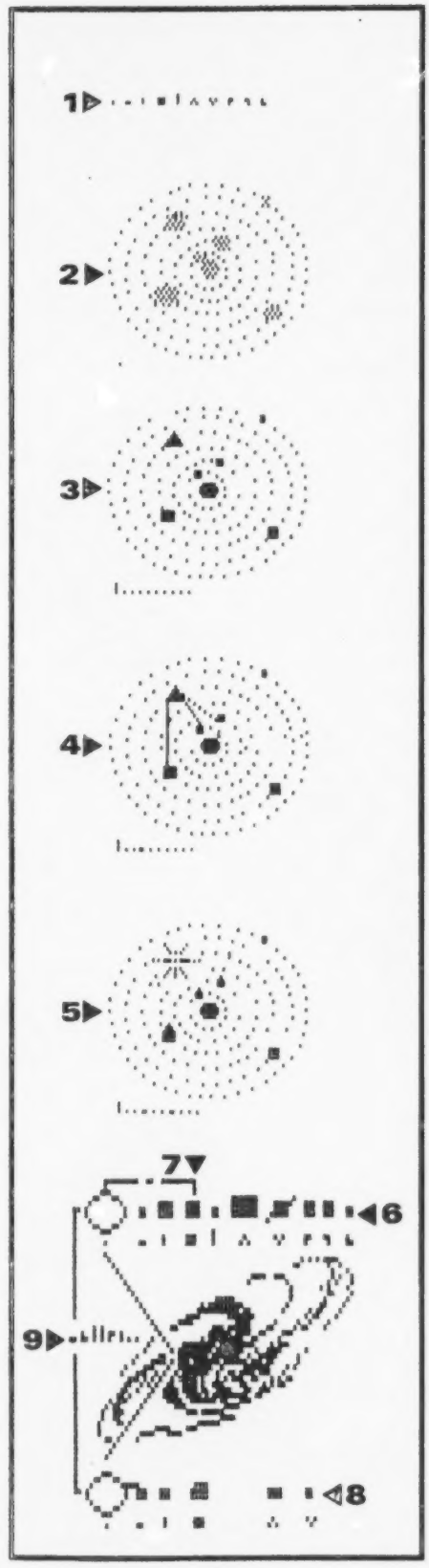
5 A schematic drawing showing that the fourth planet explodes 4,001,001,000 time units from the beginning.

6 Schematic drawing of our solar system. Note that the relative sizes of the planets are shown correctly, and that Saturn has rings. The numbering system of 0 through 9 is shown below the planets.

7 A line from our sun to the Earth, with the number 1 at the center of the line, shows that the distant civilization is using this distance to define both distance and time. The distance is 93 million miles, and the time for light to travel this distance is approximately eight minutes. This information can be used to calculate the distance to the planetary system shown in Section 9.

8 A schematic drawing of the distant civilization's planetary system. The numbering system is repeated under each planet. Note that the fourth planet is missing. The short line between the star and the first planet indicates that the message is coming from that planet.

9 A schematic drawing of our Milky Way galaxy, with lines showing the relative position of the two planetary systems. The number 19,447,200 appearing in the middle of the vertical line represents the distance, in astronomical units, between the two planetary systems. This equals almost 2 million billion miles (2,000,000,000,000,000) or 340 light years. (One astronomical unit is the distance from Earth to the sun, 93 million miles.)



COMMUNICATIONS AT WORK

NOTE TO PARENTS, TEACHERS, & YOUTH LEADERS: Children whose interest is piqued by these activities may enjoy this profile of a scientist working in a related field. Science, engineering, and technology hold bright promise as potential career pathways in the 21st century.

Jill Tarter

Astrophysicist
SETI Institute
Mountain View, CA

Specialty Leader of Project Phoenix at the SETI (Search for Extraterrestrial Intelligence) Institute, which scans the skies for radio messages from extraterrestrial civilizations on planets orbiting other stars.

Big Challenge To design a project that can check many millions of different radio frequencies at once and examine hundreds of thousands of stars in less than a human lifetime.

Top Interests Jill earned her Bachelor's degree in engineering and her doctorate in astronomy. Although SETI research occupies much of her time, she still enjoys other hands-on activities including sewing, handicrafts, small construction projects, and flying small planes.

Take It From Me "The most important thing you can do is never stop being curious. Never stop learning new things! It doesn't matter if it's cooking or quantum mechanics—if you have an interest and have a question, keep working on it until you find the answer. Ask for help from experts, or search through the World Wide Web, or even consider the old-fashioned method of reading a book! And by the way, the more math you study, the better prepared you will be to find your answers."

Connections

Copy • Distribute • Discuss

Community Link

Encourage youngsters to take home copies of the simulated message from space to ask for family suggestions as to what the distant civilization is attempting to convey to us. Family members could also be asked to give ideas for what to include in the return message.

If families have access to the Internet, suggest that they work together to explore the World Wide Web addresses listed on this page. Families without Internet access at home can often find it at a local public library or science center.

Resources

PROJECTS IN SPACE SCIENCE, by Robert Gardner (Simon & Schuster, 1988). More than 30 space-related experiments that help children explore the laws of science.

[http://www.seti-inst.edu] The SETI Institute World Wide Web site provides excellent information and links to other web sites regarding the search for extraterrestrial life.

[http://www.stsci.edu] The Space Telescope Science Institute web site provides beautiful images from the Hubble Telescope, along with classroom activities and related resources.

[http://www.physics.sfsu.edu/asp/asp.html] The Astronomical Society of the Pacific web site provides a wealth of general astronomy information and resources, with excellent links to other research and amateur astronomy resources and web sites.

Passport to Knowledge (800-626-LIVE), an on-going series of "electronic field trips to scientific frontiers," is sponsored by NSF, NASA, and the Public Broadcasting System. Projects include *LIVE FROM THE HUBBLE SPACE TELESCOPE* and *LIVE FROM MARS*.

National Science Foundation
4201 Wilson Boulevard - Room 1245
Arlington, Virginia 22230 USA

E-Mail nstw@nsf.gov

World Wide Web
http://www.nsf.gov/od/lpa/nstw/start.htm

NSTW Corporate Sponsors
AT&T • Bayer Corporation • Discover Magazine • Ford Motor Company • IBM • Merck Institute for Science Education • 3M

Resources

These organizations, programs, and services help introduce young people, as well as parents and teachers, to further hands-on learning experiences in science, mathematics, and technology. Many of them specifically support this year's NSTW theme of communication.

ORGANIZATIONS

Professional, Community, and Advocacy

American Association for the Advancement of Science

1200 New York Avenue, NW
Washington, DC 20005
Tel: 202-326-6400
[http://www.aaas.org]
[http://www.eurekalert.org]

AAAS heads a national effort to further public understanding of science. Programs include: *Barrier Free in Brief, Black Churches Project, Count on Me, Girls and Science, Proyecto Futuro, Science Books and Films, Science Education News, and SLIC: Science Linkages in the Community.*

American Chemical Society

1155 16th Street, NW
Washington, DC 20036
Tel: 800-227-5558, ext. 954
[http://www.acs.org]

ACS promotes chemistry through national public outreach and chemistry education with programs such as: *Wonder Science, Tracing the Path: African American Contributions to Chemistry in the Life Sciences, Kids & Chemistry,* and *National Chemistry Week.* (Nov. 3-9, 1997)

American Geophysical Union

2000 Florida Avenue, NW
Washington, DC 20009
Tel: 202-462-6903
[http://www.agu.org]

AGU produces various materials for the K-12 community including annotated slide sets on space physics (K-12), an emergency preparedness and response communications program (Grades 7-12), and a materials package for teachers (Grades 7-12).

Annenberg/CPB Math and Science Coalition

c/o Corporation for Public Broadcasting
901 E Street, NW
Washington, DC 20004-2037
Tel: 800-965-7373
Fax: 802-864-9846

The Coalition works in partnership with numerous science, education, and parent organizations to produce programs and materials for a base of science excellence. Its brochure, *Science...Simply Amazing!,* was produced with support from NSTW to help parents encourage children's science interest through community resources and simple activities.

ASPIRA

1444 Eye Street, NW
Suite 800
Washington, DC 20005
Tel: 202-835-3600
Fax: 202-835-3613
E-Mail: aspira1@aol.com

ASPIRA is an Hispanic advocacy group that runs leadership development and educational programs, and helps Hispanic students find scholarships.

Association of Science-Technology Centers

1025 Vermont Avenue, NW
Washington, DC 20005-3516
Tel: 202-783-7200
[http://www.astc.org/astc]

ASTC fosters public understanding of and interest in science and technology through 450 member institutions worldwide.

Association of Women in Science

1200 New York Avenue, NW
Suite 650
Washington, DC 20005
Tel: 202-326-8940
E-Mail: awis@awis.org

AWIS promotes opportunities for women to enter science fields and achieve their career goals.

Bayer/NSF Award for Community Innovation

Tel: 800-291-6020
[http://www.nsf.gov/od/lpa/events/awards.htm]

Annual competition for teams of middle-school age youth to identify real problems/challenges in their communities and propose creative solutions using science, math, engineering and technology.

The Challenger Center for Space Science Education

1029 North Royal Street
Suite 300
Alexandria, VA 22314
Tel: 703-683-9740
[http://www.challenger.org]

The Challenger Center serves a network of learning centers and education institutions throughout North America.

4-H

USDA CREES/4-H
Room 3860, South Building
14th and Independence Avenue, NW
Washington, DC 20250-0900

4-H offers internships, entrepreneurships, and mentoring by scientists in aerospace, computing, robotics, and the environment. Contact your state office or National Program Leader, Science and Technology Education.

Girl Scouts of the U.S.A.

420 5th Avenue
New York, NY 10018
Tel: 212-852-8000
[http://www.gsusa.org]

This organization offers the booklet entitled *Leading Girls to Math, Science and Technology.*

girls, inc.

30 East 33rd Street
New York, NY 10016
Tel: 212-689-3700
E-Mail: HN3578@handsnet.org

Operation SMART provides out-of-school activities that emphasize hands-on experiences in math, science, and technology for girls. (Grades 1-12)

The Institute of Electrical and Electronic Engineers, Inc.

445 Hoes Lane
P.O. Box 459
Piscataway, NJ 08855-1331
Tel: 908-981-0060
[http://www.ieee.org/]

The world's largest technical professional society, the Institute is a leading authority on areas ranging from aerospace, computers and telecommunications to electric power and consumer electronics. Possible resource for community-based volunteers, guest presenters, and project advisors.

International Society for Technology and Education

1787 Agate Street
Eugene, OR 97403
Tel: 800-336-5191
[http://isteonline.uoregon.edu]

ISTE provides education, leadership, and a forum for sharing information through its publications, such as *Learning and Leading With Technology* and educator-developed books and courseware; conferences *(Telecommunications/Multimedia Conference);* workshops; and a network of Organization Affiliates.

International Technology Education Association

1914 Association Drive
Reston, VA 20191-1539
Tel: 703-860-2100
E-Mail: itea@tmn.com
[http://www.tmn.com/Organizations/Iris/ITEA.html]

ITEA publishes *The Technology Teacher,* dedicated to the development and improvement of technology education.

Lemelson Center for the Study of Invention and Innovation

Smithsonian Institution
National Museum of American History
Washington, DC 20560
[http://www.si.edu/organize/museums/nmah/homepage/lemel/Start.htm]

The Center sponsors a *Living Role Model* series of lectures for middle-school aged children.

Math Counts

1420 King Street
Alexandria, VA 22314

This organization provides a variety of math education materials and also sponsors nationwide junior high math competitions.

National Aeronautics and Space Administration

300 E Street, SW
Washington, DC 20546
Tel: 202-358-1110
[http://www.spacelink.msfc.nasa.gov]

NASA maintains Teacher Resource Centers across the country. A complete list can be found on *NASA Spacelink* on the World Wide Web.

National Audubon Society

700 Broadway
New York, NY 10003-9562
Tel: 212-979-3000
[http://www.audubon.org/audubon/]

Through local chapters, NAS distributes *Audubon Adventures,* which often deals with animal interactions/communications. NAS is dedicated to building a culture of conservation in America through environmental education and advocacy.

National Council of La Raza

1111 19th Street, NW
Suite 1000
Washington, DC 20036
Tel: 202-785-1670

NCLR works to empower Hispanics from the grassroots and build a community of mutual respect and accountability. NCLR projects include *Project EXCEL-MAS (Excellence in Community Educational Leadership—Math and Science),* which develops community-based educational models; and *Project PRISM (Partners for Reform in Science and Mathematics),* which increases parent information about and involvement in math and science education.

National Council of Teachers of Mathematics

1906 Association Drive
Reston, VA 20191-1593
Tel: 703-620-9840
For orders only: 800-235-7566
E-Mail: orders@nctm.org
E-Mail: nctm@nctm.org
[http://www.nctm.org/]

NCTM offerings include mathematics education publications such as *Teaching Children Mathematics, Mathematics Teaching in the Middle School, Mathematics Teacher,* and over 240 educational materials.

National Science Teachers Association

1840 Wilson Boulevard
Arlington, VA 22201-3000
Tel: 703-243-7100
[http://www.nsta.org]

NSTA is committed to improving science education from preschool through college. Its *Membership and Publications Supplement* lists publications and resources, including *Science and Children, Science Scope,* and *The Science Teacher.*

National Society of Professional Engineers

1420 King Street
Alexandria, VA 22314
Tel: 703-684-2852
[http://www.nspe.org]

NSPE promotes coalitions of engineering business groups and organizations with education partners. *National Engineers Week* (February 16-22, 1997) features the *Future City* competition for students. (Grades 7-8)

National Urban Coalition

1875 Connecticut Avenue, NW
Washington, DC 20009
Tel: 202-986-1460
E-Mail: nuc@tnt.org

NUC affiliates nationwide are involved in reforming math and science education. They also sponsor the nationwide Saturday science program, *Say Yes to a Youngster's Future.*

National Urban League

500 East 62nd Street
New York, NY 10021
Tel: 212-310-9000
E-Mail: info@nul.org
[http://www.nul.org]

NUL affiliates across the country work to engage families in math and science education activities. The video, *Calculating Change,* shows ways parents and community groups can enhance math and science education.

Quality Education for Minorities Network

1818 N Street, NW
Suite 350
Washington, DC 20036
Tel: 202-659-1818
E-Mail: qemnetwork@qem.org
[http://qemnetwork.qem.org]

QEM works to improve education for minorities throughout the nation.

Resources for Involving Scientists in Education (RISE)

National Research Council
2101 Constitution Avenue, NW
(HA450)
Washington, DC 20418
Tel: 202-334-2110
E-Mail: rise@nas.edu

Contact RISE for information about involving scientists in a variety of roles in your science program.

TERC

2067 Massachusetts Avenue
Cambridge, MA 02140
Tel: 617-547-0430
E-Mail: communications@terc.edu
[http://www.terc.edu/]

TERC is a research and development organization committed to improving mathematics and science learning and teaching. Its work includes: designing telecommunications networks for teachers and students; developing network-based educational materials; creating technology tools; fostering communication in science and math classrooms; and spearheading a national initiative of science education reform for language minority students.

U.S. Geological Survey

119 National Center
Reston, VA 22092
Tel: 703-648-4463
E-Mail: srussell@usgs.gov
[http://www.usgs.gov/education/]

The U.S.G.S. uses satellite images of the earth from space to track a wide range of earth surface phenomena.

CURRICULUM & ACTIVITY GUIDES

Batteries and Bulbs

P.O. Box 3000
Nashua, NH 03061-3000
Tel: 800-442-5444

Elementary Science Study (ESS)
Nashua, NH: Delta, 1985.
(Grades 4–6)

The Computer Museum

300 Congress Street
Boston, MA 02210
Tel: 617-426-2800, ext. 307
[http://www.tcm.org/]

The Computer Museum Network, the virtual museum, lists educational resources on computer software and networking. To find sites useful for kids, check out the Network's *Links to Good Sites for Kids*. Available through the museum store are educational activities and the video *A Journey into the Walk-Through Computer*.

Electronic Discovery Trails

Liberty Science Center
Liberty State Park
251 Phillip Street
Jersey City, NJ 07305-4699
Tel: 201-451-0006, ext. 234
Fax: 201-451-6383
E-Mail: banding@lsc.org

Through distance learning, *E-Trails* invites students to explore exhibits in depth at LSC. Examples in communication include: *Create an Animal Theater Production* and *Express a Mood Without Using Words* (Grades 3–6); *Create a Secret Code* and *Create a Network* (Grades 6–12).

Foundations and Challenges to Encourage Technology-Based Science (FACETS)

Tel: 800-KH BOOKS

An educational project of the American Chemical Society, Washington, DC. *Handling Information (Module 3.8—Teacher Version)* includes six activities which help students understand how we communicate and design a communications plan. Kendall/Hunt Publishing Company, 1996. (Grade 8)

How Telecommunication Works: How People Use Energy to Communicate

Scholastic Inc., 1995

Instructional Publishing Group
555 Broadway
New York, NY 10012
[http://www.scholastic.com]

Curriculum package, part of Scholastic's *Science Place* K-6 science curriculum, that includes: equipment kits; video; a problem-solving mystery; reference literature; instructional support; and an option to link to the Scholastic Network. Examines how sound travels as energy and explores electromagnetic waves. (Grades 4–6)

How the Weatherworks

1522 Baylor Avenue
Rockville, MD 20850
Tel: 301-762-SNOW
E-Mail: hmmogil@erols.com
[http://www.weatherworks.com]

How the Weatherworks supplies educational materials related to weather, technologies designed to communicate weather information, and National Sky Awareness Week, which occurs simultaneously with NSTW (April 20–26, 1997). *Weather Study Under a Mass Media Umbrella* includes activities for using television, newspaper, and the Internet to bring real-time weather data into the classroom. (Grades 4–12)

Inventure Place

National Inventors Hall of Fame
221 S. Broadway
Akron, OH 44308
Tel: 216-762-4463
[http://www.invent.org]

Inventure Place, the National Inventors Hall of Fame, is a hands-on, interactive museum that presents the great inventors of our time and unique exhibits featuring fiber optics, lasers, videos and more.

The Journey Inside: The Computer

Intel
P.O. Box 7620
Mount Prospect, IL 60056-9960
[http://www.intel.com/intel/educate/index.htm]

The Journey Inside from Intel Corp. provides in-depth, easy-to-use materials free of charge to science, math and computer teachers in grades 5–9. The kit includes a 300-page, six-module teacher's guide, a six-part video, and a hands-on chip kit. The study units cover an introduction to computers; how microprocessors work; what digital information is; how transistors work; how computer chips are made; and an examination of critical inventions throughout history.

Kids & Technology

Mission21: Launching Technology Across the Curriculum
Delmar Publishers, Inc. 1992

2 Computer Drive West
Box 15-015
Albany, NY 12212

A hands-on, activity-based supplementary technology and science program for grades 1–6. The problem-solving unit, *Communication*, explores why and how people communicate, modern communication, communication technology, and the future of communication.

Teacher's Resource Book, Level III
(Grades 5–6)

Lawrence Hall of Science

University of California at Berkeley
Berkeley, CA 94720-5200
Tel: 510-642-7771

Great Explorations in Math & Science (GEMS)
GEMS teacher's guides enable teachers to incorporate activity-based science and math learning into their curriculum in a flexible manner (Pre-K–10). In *Buzzing a Hive* (Grades K–3), students learn about bee communication; *Oobleck: What Do Scientists Do?* contains activities that focus on how scientists communicate their findings.

Science Activities for the Visually Impaired/Science Enrichment for Learners with Physical Handicaps (SAVI/SELPH)
Multisensory Learning: 1982.
Tel: 415-642-8941

In the *Communication Kit*, students listen for specific sounds and then develop a code using sounds to send a message, plus other activities. As part of the *Magnetism and Electricity* unit, students construct a telegraph and conduct other experiments related to magnetism and electricity. (Grades 4–7)

Out of This World

AIMS Education Foundation
P.O. Box 8120
Fresno, CA 93747-8120
Tel: 209-255-4094

AIMS Activities: 1994
Activities that relate to space communication include: *How Long Does It Take to Say Hello?*, which asks students to compute the time it would take for a message to reach the moon and the planets; and *Space Talk Message*, wherein students compute the time needed to send a series of messages between the moon and the planets. (Grades 4–8)

Passport to Knowledge

P.O. Box 1502
Summit, NJ 07902-1502
Tel: 608-786-2767
Tel: 800-626-LIVE (for up-to-date information on projects)
Fax: 608-786-1819
E-Mail: janw@quest.arc.nasa.gov
[http://quest.arc.nasa.gov]

Interactive electronic projects include *Live from the Hubble Space Telescope,* which can be accessed through the teacher's guide and video of the telecasts. *Live from Mars* can be found on the NASA K12 Internet Initiative web site. Also new for 1997 is *Live from Antarctica II.*

The Science Source

P.O. Box 727
299 Atlantic Highway
Waldoboro, ME 04572
Tel: 207-832-6344
Fax: 207-832-7281

The Science Source produces hands-on educational equipment that demonstrates principles of communication from optics and image formation to visual displays of the working of sound waves.

Smithsonian Resource Guide for Teachers, 1996/97

Office of Elementary and Secondary Education
Smithsonian Institution
Arts & Industries Building
Room 1163, MRC 402
Washington, DC 20560
[http://www.si.edu/]

This guide includes extensive listings of education materials available from all of the Smithsonian's member organizations.

Wonders of Learning Kit
Ways Animals Communicate

National Geographic Society
Tel: 800-368-2728
(Grades 3-6)

ADDITIONAL REFERENCES ON COMMUNICATION

Communication Satellites, Their Development and Impact

Hulson, Heather E.
The Free Press
New York: A Division of Macmillan and Co., 1990

Communication Technology

Barden, Robert, and Hacker, Michael
Albany, NY: Delmar Publishers, 1997

Communication Technology
Today and Tomorrow

Sanders, Mark
New York: Glencoe/McGraw Hill, 1997

The Communications Miracle

Bray, John
New York: Plenun Press, 1995

Easy-to-Build Transistor Projects

Buckwalter, Len
New Augusta, IN: Editors and Engineers, Ltd., 1965

Electricity

Learning Through Science
Kincaid, Doug, and Richards, Roy
London, England: Macdonald, 1983
ISBN 0-356-07658-3
Teacher's Laboratory

"Learning to Telecommunicate"

Ljutic, Anton
Learning and Leading with Technology
Vol 23, #8, 1996

"Open Learning Credits in the United Kingdom"

Emms, Steve
Learning and Leading with Technology;
Vol 23, #5, 1996

State of the Art, A Photographic History of the Integrated Circuit

Augarten, Stan
New Haven: Ticknor and Fields, 1983

Wires and Watts

Mat, Irwin
New Haven: Charles Scribner and Sons, 1981

World Book, Inc.

1560 Sherman Avenue
Evanston, IL 60201

Particular books of interest are:
Science Yearbook and *Science Power.*

VIDEOS, INTERACTIVE CD-ROM, LASER DISCS, SOFTWARE

(Grade level is listed in parentheses for each item. Where no address or phone number appears, check your local library, or educators can check their local education service directories.)

American Sign Language Dictionary
(CD-ROM)

Laser Learning Technology

Animal Pathfinders
(Software)

Nova, 1990

Elementary Electricity
1993 (23 min. video)

National Geographic Society.
No. G51568.
Tel: 800-368-2728

Covers the history of the incandescer light, including principles of conductivity, circuits, and magnetism. (Grades K-4)

Exploring Sound
(10 min. video)

The Media Guild, San Diego, CA
Exploring Science Series

Story of a boy with a cold whose ears stuff up but pop with a sneeze. Awareness of sound and basic concepts are developed, and, through a series of simple examples, pitch, loudness, vibration and sequence are demonstrated. (Grades 3-6)

Guide to North American Birds
1996 (CD-ROM)

Knopf New Media
201 East 50th Street
New York, NY 10022
Tel: 800-733-3000

Produced by the National Audubon Society, this interactive CD includes songs of birds as well as other information about birds. (Grades 4-12)

Inter@ctive Explorer Series Programs
MECC (IES Order)
6160 Summit Drive North
Minneapolis, MN 55430-4003
Tel: 800-375-0055
[http://www.mecc.com/]

MayaQuest '97 Oregon Trail Online

Invention: Mastering Sound

Discovery Interactive Library Laserdisc

Shows how inventors created inventions that revolutionized the way we communicate.

Sign, Sign, Sign
1988 (106 min. video)

HANDSUP VIDEO ENTERPRISES
P.O. Box 468
Howell, NJ 07731

A program teaching over 300 signs, using each one repeatedly in sentence Includes the alphabet, words, sentences, conversations, and more. (Grades K-8)

Signs of the Apes, Songs of the Whales/Adventure in Human-Animal Communication
(57 min. video)

Ambrose Video Pub., New York
(NOVA Presentation) (Grades 8-12)

Telephone Line
(17 min. video)

New Dimension Media, Inc.
Eugene, OR 97405

History of the telephone and the contemporary communications possible through the telephone line. Covers fiber optics, use of the 911 number and broad band networking through the telephone. (Grades 1–4)

The Nature of Things: Radar: Visions from Space
1990 (30 min. video)

New Dimensions

This video explains how developments in communication have heightened scientists' knowledge of climate patterns, geology, and the environment. (Grades 6–12)

The Way Things Work
(CD-ROM)

Macauley, David
Dorling Kindersley Multimedia
Houghton-Mifflin Company

Trade Book Resources

Follett Software Co.
1391 Corporate Drive
McHenry, IL 60050–7041
Tel: 800-323-3397

Find It! Science is an innovative, multimedia CD-ROM product containing more than 2,500 award-winning and highly recommended science-related trade books.

Trials of Life: Talking to Strangers
1992 (60 min. video)

Ambros Video Publishing,
Turner Broadcasting and the BBC.

Explores how animals meet the test of survival and the ways animals communicate from continents all over the world. Includes land animals as well as sea creatures. (Grades 6–8)

What's the Secret?
(CD-ROM)

3M Software Media and
CD-ROM Services
3M Center, Building 223-5N-01
St. Paul, MN 55144–1000

A three-disc interactive CD-ROM series based on the Emmy Award-winning PBS science series, *Newton's Apple*, and produced by 3M. A science adventure for the curious of all ages.

Wireless Coyote
(video)

Apple Computer, Inc.

Small classroom collects field data on-site using computers, cellular phones, and other technological instruments. (Grades 8–12)

Your Town Series II: Communications,
1992 (15 min. video)

National Geographic Society,
No. G51494.

Explores the different ways a community stays informed. (Grades K–3)

ELECTRONIC MEDIA

AT&T Learning Network

Tel: 800-809-1097
E-Mail: learningnet@attmail.com
[http://www.att.com/learning-network/]

The AT&T Learning Network is a commitment to help connect America's schools to the Information Superhighway by the year 2000. This website also includes information on AT&T's support for teachers and communities and a technology planning check list.

Bill Nye the Science Guy

Outreach Department
KCTS
401 Mercer Street
Seattle, WA 98109–9721
[http://nyelabs.kcts.org/]

This PBS children's science series explores science in a fast-paced, entertaining format. Previous episodes related to communication include: *Communication, Waves, Sound, Electricity-Current, Computers,* and *Magnetism.* The Teacher's Kit contains a complete list of episodes, recording rights information and hands-on science activities related to the topics presented in the series. Children may write KCTS to obtain a free subscription to *The Big News of Science*, a twice-yearly newsletter about the show.

CU-SeeMe

K-12 Global School Network
[http://www.gsn.org/]

The network connects kids and schools across the nation and provides interactive classroom projects using the Internet.

Earth & Sky

P.O. Box 2203
Austin, TX 78768
Tel: 512-477-4441
[http://www.earthsky.com]

Earth & Sky is an award-winning, NSF-funded radio show, presenting natural science in a way that is fun, interesting, and easy to understand. The show airs every day on more than 800 public and commercial radio stations in the U.S. and Canada. The Young Producers Contest encourages teams of K–12 students to create science radio programs for *Earth & Sky* broadcasts.

Everyday Science

WQED
4802 5th Avenue
Pittsburgh, PA 15213
Tel: 412-622-1436

A daily two-minute science module on public radio, *Everyday Science* is part of "Making Science Make Sense," a Bayer initiative emphasizing hands-on science education programs and a campaign to promote science literacy. Check your local PBS station for broadcast times in your area.

Kinetic City Super Crew

AAAS, Department I
1333 H Street, NW
Washington, DC 20005
Tel: 888-GET-CREW
[http://www.aaas.org/ehr/kcsuper.html]

Produced by AAAS with NSF funding, this radio show by and for students stimulates the imagination of 8– to 12- year-olds in a 30-minute weekly format and is broadcast nationwide.

Magic School Bus

1101 George Rogers Boulevard
P.O. Box 11000
Columbia, SC 29211
Tel: 803-737-3437
Fax: 803-737-3435
E-Mail: msbfun@scholastic.com
[http://scholastic.com/MagicSchoolBus/index.html]

The award-winning *Magic School Bus* series, aimed at kids 6–9 years old, inspires youngsters to engage in science activity in school and at home. Teachers may videotape the programs and use them for three years with their classes. Contact your local PBS station to obtain a free teacher's activity guide.

National Geographic Kids Network

National Geographic Society
Educational Services
Dept. 5397
Washington, DC 20036
Tel: 800-368-2728

The network provides opportunities for students to collect and share original scientific data with other students and professionals. For example, the unit *Hello* teaches students in grades 4–6 about scientific research methods, telecommunications, and other computer tools.

National Public Radio
Talk of the Nation: Science Friday

National Public Radio Outreach
635 Massachusetts Avenue, NW
Washington, DC 20001-3753
Tel: 202-414-2000

NPR discusses both mainstream and off-beat science topics in this NSF-funded program. Teaching materials include *Science Friday on Location.*

The New Explorers

The Chicago Production Center/WTTW
5400 North St. Louis Avenue
Chicago, IL 60625

This PBS television series brings exciting scientific adventures and discoveries into classrooms across the country. A 24-page, full-color *New Explorers Activities Guide* is available to teachers free at the above address.

Newton's Apple

KTCA
Twin Cities Public Television
The Minnesota TeleCenter
172 East Fourth Street
Saint Paul, MN 55101
Tel: 612-222-1717
[http://www.mnonline.org/ktca/newtons]

Newton's Apple, the Emmy Award-winning PBS family science series, explores science using an inquiry-based approach to learning. Educational programs engage the viewer in topics such as: *Music Synthesis; Supercomputers; Faxes; Computer Virus; How TV Works; Satellite Technology; How a Newspaper Gets Produced; What Is an Echo; Internet; Hubble Telescope;* and *Electrical Circuits.*

PBS Web Page

Connection to PBS' K-12 Learning Services including:

E-Mail: k12@pbs.org (Science Internet)
mathline@pbs.org (PBS Mathline)
[http://www.pbs.org/]

Science Learning Network

[http://www.sln.org/]

The *Science Learning Network (SLN)* is a partnership among six science museums which provide support for teacher development and science learning. SLN receives funding from NSF and Unisys Corporation.

Scientific American Frontiers

105 Terry Drive
Suite 120
Newtown, PA 18940
Tel: 800-315-5010
[http://www2.pbs.org/saf/]

A PBS television series starring Alan Alda and exploring discoveries in science and technology. Free teaching materials and off-air taping rights are available.

Soundprint

4000 Brandywine Street, NW
Suite 620
Washington, DC 20016
Tel: 202-885-1285
[http://www.soundprint.org]

A weekly half-hour documentary radio series, funded in part by NSF, that includes science and technology topics.

Teacher to Teacher

Mr. Wizard Foundation
44800 Helm Street
Plymouth, MI 48170
Tel: 800-258-2344

This Nickelodeon TV series, produced for teachers, shows exceptional teachers providing activity-based science programs.

CATALOGS

Eisenhower National Clearinghouse

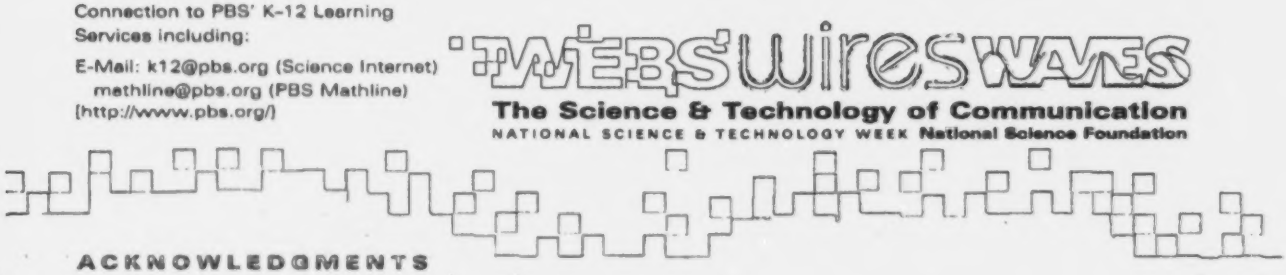
1929 Kenny Road
Columbus, OH 43210-1079
[http://www.enc.org/]

The clearinghouse offers an assortment of services for K-12 teachers to quickly locate educational resources including an online catalog.

LEGO Dacta

555 Taylor Road
Enfield, CT 06082

LEGO Dacta provides high-quality manipulatives, curriculum materials, and related products for early childhood, science, mathematics, technology education, and computer-related subject areas.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National Science Foundation
4201 Wilson Boulevard - Room 1245
Arlington, VA 22230 USA
E-Mail: nstw@nsf.gov
[http://www.nsf.gov/od/lpa/nstw/start.htm]

Evaluation Form

FOR EDUCATORS AND YOUTH LEADERS

Answering this questionnaire will assist us in developing future National Science & Technology Week (NSTW) materials. One hundred respondents will be chosen in a random drawing during NSTW'97 and will receive sets of beautiful, full-color NSTW posters selected from the past 12 years. Thank you for your help.

1 **Please write your name and complete mailing address here:** *(Include electronic address if you have one.)*

NAME _____

ADDRESS _____

_____

CITY _____

STATE _____ ZIP _____

E-MAIL ADDRESS _____

3 **How did you receive this packet?**

- ☐ From a site of the NSTW Regional Network
- ☐ Direct mail
- ☐ By oral or written request
- ☐ At a school: Principal/Teacher
- ☐ By attending a workshop
- ☐ Through an electronic notice: Internet/World Wide Web
- ☐ Other *(please specify)*

_____

_____

4 **What did you specifically like about each activity you used?**

_____

_____

_____

5 **What changes would you make to individual activities or to the activities packet as a whole?**

_____

_____

_____

6 **What topics would you like to see explored in future NSTW activities?**

_____

_____

7 **Do you have access to the Internet?**

☐ yes ☐ no

Do you have access to the World Wide Web?

☐ yes ☐ no

8 **Are you a:**

☐ **Parent** ☐ **Teacher**

☐ **Leader** ☐ **Other** *(please explain)*

_____

_____

9 **Do you prefer that these materials come as separate 8-page booklets or as one book encompassing all of the activities, as was done last year?**

☐ separate units ☐ one book

2 **Please check each booklet you used and add the requested comments:**

	OVERALL EVALUATION *(low)*				*(high)*	FIT WITH EXISTING CURRICULUM *(not at all)*				*(very well)*
☐ 1 Communicating Naturally	1	2	3	4	5	1	2	3	4	5
☐ 2 Communicating With Codes	1	2	3	4	5	1	2	3	4	5
☐ 3 Communicating Through Wires	1	2	3	4	5	1	2	3	4	5
☐ 4 Communicating Through Radio Waves	1	2	3	4	5	1	2	3	4	5
☐ 5 Communicating Through Networks	1	2	3	4	5	1	2	3	4	5
☐ 6 Communicating Into Space	1	2	3	4	5	1	2	3	4	5

If you didn't use one or more of the booklets, why not?

_____

_____

(Please duplicate for other teachers, instructors, or parents. After completing form, simply fold, seal, and mail or fax to 703-306-0157.)

Printed with SOY INK

Please describe any use you plan to make of these teaching activities during NSTW 1997.

Additional Comments:

NATIONAL SCIENCE & TECHNOLOGY WEEK
National Science Foundation
4201 Wilson Boulevard - Room 1245
Arlington, Virginia 22230 USA

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WEBS wires WAVES

The Science & Technology of Communication

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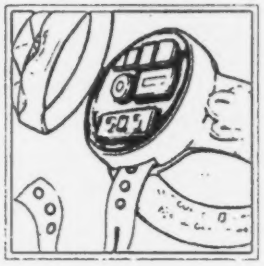

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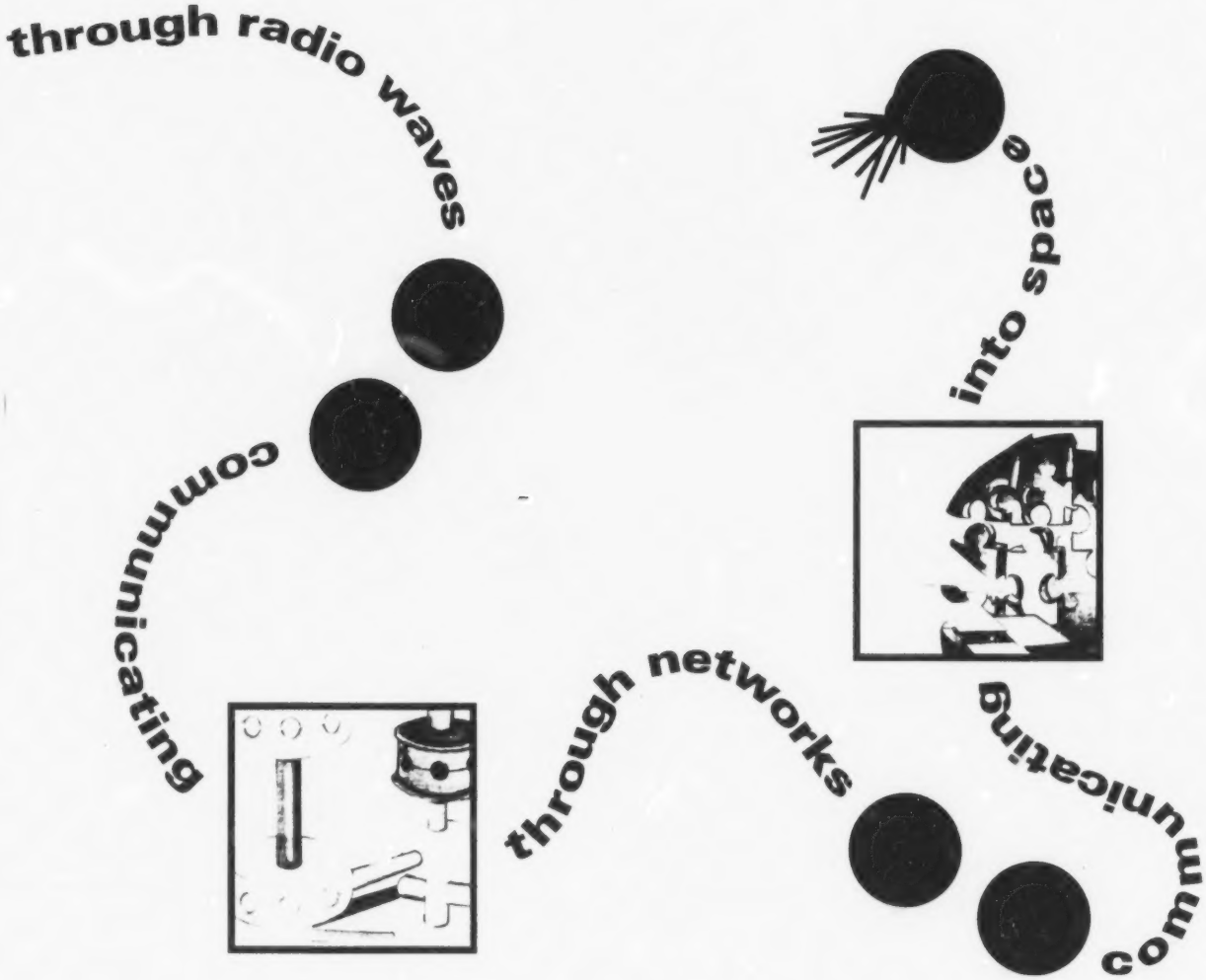

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OFFICE OF THE
DIRECTOR

Fall 1996

National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

Dear Educator or Youth Leader:

There may be no work more critically important to the future of our society than your efforts to fire the interest of young people in science, mathematics, engineering, and technology. The people of the National Science Foundation are proud to support those efforts with this annual packet of dynamic, accessible hands-on activities.

As always, this year's activities revolve around the theme of National Science & Technology Week (NSTW), to be celebrated April 20-26, 1997. ***Webs, Wires, Waves: The Science & Technology of Communication*** is designed to help children explore and understand the myriad (and increasingly complex) ways we communicate with one another. By creating simple codes, building paper-cup telephones, and demonstrating the power of networks using ping-pong balls, your youngsters will be applying the same principles that make our global communications system work—and, we hope, having a lot of fun in the process.

Whether you are a teacher, a parent, a scout or club leader, or a volunteer coach in your community, we encourage you to put these activities to use and hope that you'll enhance their value by participating in or sponsoring NSTW events in your area. Thank you, in advance, for joining with us to help attract a future generation of scientists, engineers, and informed citizens to the spirit of learning and adventure that assures a bright future for us all.

Sincerely,

Neal Lane

Neal Lane
Director

Please share these activities with teachers, club leaders, parents—all those who encourage children to connect with the world of science and technology. We encourage the duplication of these activities.

About This Packet

The six 8-page booklets within this packet present activities that follow a pathway from natural, simple forms of communication toward increasingly complex and technological forms. They are designed to be undertaken in sequence, but can also stand alone as independent units. Each activity is recommended for an appropriate age range, but most can also be adapted for use with younger or older children. All booklets include features of assessment, extension, and home/community connections.

A seventh insert, *Resources*, presents a wide range of resources beyond these activities that you can use to extend the activities, while this poster (see reverse side) can announce your participation in NSTW'97. Please share your experience and comments by returning the evaluation form!

WEBS wires WAVES

Communication: So central to the way we live, and yet how many of us can explain how a telephone really works? Or how a radio snatches a song—seemingly out of thin air?

The mission of National Science & Technology Week 1997, sponsored by the National Science Foundation and its corporate and associate sponsors, is to focus the nation's attention on the secrets of communication technology and to encourage children to engage in the processes of science and engineering by exploring those secrets. The materials contained in this packet offer a wide range of hands-on activities for use by children as young as five years old, in settings both inside and outside of school.

The six eight-page booklets in this packet represent a spectrum of communications activities—from natural, non-technological forms of communication in Booklet 1 to more complex forms requiring the use of codes, wires, radio waves, and networks in the booklets that follow.

These hands-on explorations can be the beginning of your celebration of National Science & Technology Week, when demonstrations and celebrations can highlight youngsters' performance of these activities. To learn about NSTW events in your area or to learn how you can become more involved, please contact NSF *(see below)*. You'll be put in touch with the NSTW Regional Network member nearest you. The 46-site Network organizes local training events for teachers and informal educators, including parents, and joins with community partners in sponsoring events and activities celebrating National Science & Technology Week, April 20-26, 1997. You can learn more about Network activities on NSTW's Web page.

Address all correspondence to NSTW Staff at the following addresses:

National Science & Technology Week
National Science Foundation
4201 Wilson Boulevard–Room 1245
Arlington, VA 22230 USA

E-Mail: nstw@nsf.gov

World Wide Web:
[http://www.nsf.gov/od/lpa/nstw/start.htm]

1|Communicating Naturally
SCENTS & SENSE ABILITIES

Overview
Children model and explore various natural (non-technological) methods of animal communication, each involving the senses of sight, sound, touch, or smell. These activities also introduce the concept (expanded in Booklets 3 and 4) of vibration as the foundation of all sound.

Skills
Observing, Comparing, Modeling, Inferring, Problem-Solving, Communicating

Subject Areas
Animal Science, Language Arts, Physics

Estimated Time and Age Level
- Going Through the Motions
  One 30-minute session (ages 5-10)
- Calls of the Wild
  One 30-minute session (ages 6-10)
- The Nose Knows
  One 45-minute session (ages 6-12)

2|Communicating With Codes
GET THE MESSAGE?

Overview
Using a code to transmit a message is the first step towards understanding today's more complex and technological forms of communication. In these activities, children discover the importance of codes by sending distress signals from the *Titanic*, cracking coded song lyrics, and creating an egg-carton "binary decoder."

Skills
Classifying, Collecting and Organizing Data, Interpreting, Problem-Solving, Analyzing, Communicating

Subject Areas
Information Science, Mathematics, Language Arts

Estimated Time and Age Level
- SOS Titanic
  One 45-minute session (ages 7-12)
- Code Masters Rule!
  Two 45-minute sessions (ages 8-14)
- Two Bits, Four Bits
  Two 45-minute sessions (ages 8-14)

3|Communicating Through Wires
HOW SOUND GETS AROUND

Overview
Youngsters will learn what makes electronic communication possible by constructing a rudimentary telephone and electronic speaker out of ordinary materials.

Skills
Recording Data, Measuring, Observing, Inferring

Subject Areas
Physics, Technology

Estimated Time and Age Level
- Good Vibrations
  One 30-minute session (ages 7-11)
- String It Along
  One 40-minute session (ages 8-12)
- Listen Up!
  One 50-minute session (ages 11-14)

The Science & Technology of Communication

"Calling All Future Scientists and Engineers...."
Note: The experiences that youngsters gain from exploring these activities may lead them to consider further studies and potential career choices. To help them understand and appreciate the value of a career in science, engineering, or technology, each 8-page booklet concludes with a brief profile of a specialist working in one of those fields. The following Q&A outlines the importance of this "school-to-career" emphasis.

Q: *What's at stake?*

A: The U.S. will need a full supply of new scientists and engineers (as well as citizens literate in these fields) in order to progress in the next century. Too many children lose interest in science just at the age when it should be captivating them. These NSTW hands-on activities are intended to help teachers, parents, and youth leaders solve that problem—by sparking a lifelong appreciation of the joy of scientific discovery.

Many children—especially those from economic or demographic groups that are underrepresented among math/science professionals—grow up without ever seeing or meeting a working scientist or engineer. There are great opportunities for young people of all backgrounds in these fields. But the children need to see that it's possible first: that people who look just like them are working hard, asking and solving the great science and engineering questions of the day.

Q: *Who are the specialists profiled in the activities?*

A: These scientists and engineers, in their studies and careers, simply illustrate the possibilities that we hope all children will imagine for themselves through their own hands-on learning experiences in pursuing these activities.

Q: *What else can teachers, parents, and youth leaders do to help?*

A: Take advantage of events such as NSTW to bring scientists and engineers into your classrooms, homes, or youth groups. There is no substitute for personal contact—and most people who work in these fields are glad to serve, if only they're asked to help.

4|Communicating Through Radio Waves
FREQUENCY FLYER

Overview
Youngsters will learn about radio communication and the electromagnetic spectrum by producing their own radio waves—and then figuring out how they did it.

Skills
Recording Data, Measuring, Observing, Hypothesizing, Using Models

Subject Areas
Physics, Technology

Estimated Time and Age Level
- Making Waves
  One 50-minute session
  (ages 10–14)
- Seeing the Light
  One 60-minute session
  (ages 10–14)
- Tuning In
  One 40-minute session
  (ages 8–14)

5|Communicating Through Networks
GET CONNECTED

Overview
Children are challenged to build a three-dimensional network to move coded ping-pong ball messages around a room. In doing so, they will use the basic components of all telecommunications links: input, transport, switch, and output.

Skills
Teamwork, Problem Solving, Building a Model, Reasoning from Observation, Comparing, Communicating

Subject Areas
Physics, Technology, Engineering, Information Science, Math, Language Arts

Estimated Time and Age Level
- The Great Communi-Contraption
  Three to six 45-minute sessions
  (ages 10–14)
- "Testing, Testing, 1-10-11..."
  Two 45-minute sessions
  (ages 10–14)

6|Communicating Into Space
THE SKY'S NO LIMIT

Overview
Youngsters will learn how images (from television shows to pictures from the Hubble Space Telescope) are transmitted over radio waves, and then use problem-solving skills to interpret a simulated message from a civilization orbiting a distant star.

Skills
Recording Data, Comparing Information, Interpreting Data, Problem-solving

Subject Areas
Mathematics, Information Science, Design, Astronomy

Estimated Time and Age Level
- Pixel Me This
  Two 45-minute sessions
  (ages 8–12)
- Reading You Loud and Clear
  Three 45-minute sessions
  (ages 10–14)